SNAP LAKE MINE

Final Closure and Reclamation Plan

March 2019

De Beers Group
**REVISIONS HISTORY**

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1. **PLAIN LANGUAGE SUMMARY**

Careful preparation for mine closure is an important part of responsible mine planning. In the Northwest Territories, mining companies must update closure and reclamation plans throughout a mine’s life, with the plans becoming more detailed as the mine approaches closure.

This document is the Final Closure and Reclamation Plan (FCRP) for the Snap Lake Mine, updating the plan to close and reclaim the mine site, with more information on current conditions at the mine, the latest research on reclamation, and more detailed engineering plans. This plain language summary focuses on a smaller number of topics than the full FCRP; interested readers are encouraged to review the full technical plan for more detail.

The FCRP describes the actions De Beers Canada Inc. (De Beers) will take to close the Snap Lake Mine. To prepare the FCRP, De Beers followed guidelines set by Indigenous and Northern Affairs Canada and the Mackenzie Valley Land and Water Board.

1.1 **The Snap Lake Mine**

The Snap Lake Mine (the Mine) is a former underground diamond mine operated by De Beers, located about 220 kilometres northeast of Yellowknife in the Northwest Territories. The Snap Lake Mine operated from 2008 to 2015, when De Beers put the Mine into a temporary closure phase called Care and Maintenance. With regulatory approvals in place, at the beginning of 2017 the Mine was allowed to flood with water. The company has since announced its plan to put the Snap Lake Mine into final closure. While De Beers prepares for closure, Extended Care and Maintenance (ECM) has been continued at the site according to a plan approved by the water board.

The Mine includes both underground workings and surface facilities. These surface facilities (Figure 1.1) include the North Pile, processing plant complex (Figure 1.2), water management structures, water treatment plant, fuel storage facilities, roadways, an airstrip, laydown areas, and various buildings.

1.2 **Project Environment**

The condition of the natural environment, including how it has changed as a result of the Snap Lake Mine, is important for closure planning. Information on the environment surrounding the Mine has been collected since before it was built.

The Mine is located on a gently sloping plain scattered with large boulders and frost-shattered rock on the northwest peninsula of Snap Lake. This area is mostly underlain by permafrost, a layer of ground that is always frozen. The North Pile, which is the facility constructed to dispose of crushed kimberlite rock that diamonds were collected from, has started to freeze from the bottom up with permafrost too. Snap Lake has numerous islands, rocky outcrops, and shoals, and many small streams of varying lengths drain away from it. Although water levels in Snap Lake were predicted to change as a result of the Mine, those changes have not occurred.
Figure 1.1  Layout of the Snap Lake Mine

Figure 1.2  View of the Processing Plant Complex
Before the Mine was built, seven species of fish were captured in Snap Lake: longnose sucker, burbot, lake trout, round whitefish, Arctic grayling, lake chub, and slimy sculpin. The results from a recent fish study showed that the fish community in Snap Lake was similar to what was seen in previous years. A monitoring program completed in 2016 concluded that there are no signs that fish in Snap Lake are being affected by the Mine, and that the fish in the lake are healthy and abundant.

Snap Lake and the surrounding lakes and streams also contain other forms of life besides fish. The amount of **phytoplankton** (one-celled plants, like algae) in Snap Lake has increased since the Mine was built, probably because of the additional nutrients mining activities have introduced to the water. Similarly, small organisms called **benthic invertebrates** (small organisms that live at the bottom of lakes and streams) are more abundant than they were previously. **Zooplankton** (tiny water-dwelling animals) have not changed compared to the years before the Mine.

Fine dust can be generated by wind blowing over the landscape, as well as by mining activities like moving vehicles or construction. Burning fuel in generators produces dust and gas emissions. Air quality at the Snap Lake Mine has been monitored using sampling equipment that measures dust both suspended in the air and deposited on land. Other samplers measure gas emissions from diesel generators and mine equipment, which are also calculated based on the amount of fuel burned. Dust and gas emissions, which increased after the Snap Lake Mine began operating in 2008, decreased from 2012 to 2015, partly because De Beers used more fuel-efficient equipment. Since the mine went into Extended Care and Maintenance, emission levels have dropped even lower.

The Mine is located within a type of sub-Arctic forest called the **taiga**, which forms a transition between the forested lands to the south and open tundra (or barren lands) to the north. The taiga is known for cooler air temperatures and a short growing season for vegetation. The few plants that thrive have adapted to the harsh climate and poor soils: stunted stands of black and white spruce trees, along with dwarf birch, willow, flowering shrubs, cotton grass, lichens and mosses. Construction and operation of the Snap Lake Mine has disturbed about 188 hectares of vegetation, slightly less than what was predicted before the mine was built. De Beers is planning revegetation in these disturbed areas, as described in a later section of this summary.

The area around the Snap Lake Mine is home to many different types of wildlife. Wildlife studies at the Snap Lake Mine have focused on caribou, grizzly bears, wolverines, wolves, foxes, upland breeding birds (such as shorebirds and ptarmigan), raptors (such as peregrine falcon and gyrfalcon), and waterfowl.

The Bathurst caribou herd winters south of the treeline, gathering in the spring to migrate north to their calving grounds west of Bathurst Inlet, and returning south to the wintering grounds after calving. During the life of the Mine, caribou have been monitored using satellite collars, helicopter surveys, the recorded observations of Mine employees. The number of caribou seen has varied greatly from year to year since monitoring began in 1999, likely because the size of the Bathurst caribou herd has decreased. In 2012, one caribou was observed during two post-calving migration aerial surveys, while in 2014, 226 caribou were observed during an aerial survey.

Signs of grizzly bear presence were spotted in the area around the Mine in 2001 and 2002, though no active grizzly bear dens have been found. Snow track surveys confirm the presence of wolverine in the area, and the animals were sighted every year from 1999 through 2002. Eskers (the beds of streams that once
ran under glacier ice) on the landscape provide important travel routes for many mammal species such as caribou, muskox and furbearers, as well as den sites for carnivores, especially wolves. The locations of all active wolf and fox dens along eskers were recorded during surveys in 1999 and 2000. The number of active wolf dens in the study area ranged from two to five from 1999 through 2002. The area is also shared by 23 species of upland breeding birds and eight species of raptors. From 1999 to 2010, 12 falcon nest sites were observed in the study area.

1.3 Closure and Reclamation

Closure of the Snap Lake Mine will happen in two phases. First, during the eight-year Closure phase, mine facilities will be decommissioned or demolished, water management systems will be adapted for Closure, and the land will be reshaped and revegetated. Second, during the Post-Closure phase, which is expected to continue for a minimum of ten years, monitoring programs will be put in place to check that the Snap Lake Mine is meeting closure goals and ensuring the successful long term closure of the site.

1.3.1 Closure Phase

De Beers’ overall goal for the Snap Lake Mine is:

*To return the site and affected areas around the Mine to technically viable and, where practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities.*

De Beers’ FCRP includes plans for each of the mine components. The FCRP provides closure objectives for the mine, including objectives to be applied site-wide and those that relate to specific mine components.

De Beers’ seven objectives that apply to the entire Snap Lake Mine site are:

1. Dust levels that are safe for people, vegetation, aquatic life and wildlife.
2. Surface runoff drainage pathways that are physically stable.
3. Surface runoff and seepage water quality that are safe for people, vegetation, aquatic life, and wildlife.
4. Mine areas that are physically stable and safe for use by people and wildlife.
5. The shape of the landscape and the vegetation on the landscape match that of the surrounding natural area.
6. Safe passage and use of the site for caribou and other wildlife.
7. Revegetation of the site, focused on priority areas.

Figure 1.3 provides a map of the site in the Post-Closure Condition when all of these objectives would be achieved.
Figure 1.3  Post-Closure Conditions
The following sections briefly summarize the closure plan and objectives for each of the major mine components.

**1.3.1.1 Underground Mine**

The underground workings at the Snap Lake Mine (Figure 1.4) were used to extract *kimberlite*, a rock that often contains diamonds. In early 2017, as part of Extended Care and Maintenance, major structures and equipment and all hazardous materials were removed from the underground mine, and the workings were then flooded. Access to the underground mine has been temporarily sealed (Figure 1.5). Discharge of mine water has been stopped, and ventilation of the underground workings has been turned off.

To complete closure of the underground, all surface features will be decommissioned and sealed, and ventilation will be capped with concrete.

**De Beers’ three objectives for the closure of the underground mine are:**

1. No impacts to aquatic habitat and fish community in lakes due to mine flooding.
2. Ground and surface water that is uncontaminated by contributions from the mine.
3. Mine workings that are physically stable.

**Figure 1.4 Ramp to the Underground Mine during Operations**

![Ramp to the Underground Mine](image-url)
1.3.1.2 North Pile and Water Management Structures

The North Pile is a surface disposal facility approximately 92 hectares in area and 32 metres in height (Figure 1.6). When the Project was operating, the North Pile was used to store processed kimberlite, waste rock, and non-hazardous solid waste. A number of water management structures, including the Water Management Pond, are used to move and treat water at the Mine.

As part of mine closure, the North Pile will be covered with an engineered cover, and the pile will be smoothed to allow water runoff and safe passage by wildlife species. The cover design has focused on ensuring the North Pile will be stable over the long-term without the need for on-going maintenance. This meant shaping the pile so that it is not too steep, and designing a cover with material that is resistant to wind and water erosion, that is thick enough in the right places to make sure that landfilled materials are isolated from the surrounding environment. Vegetation growth on the surface of the pile is expected to happen naturally.

Water that runs off of the covered North Pile will be collected in two Influent Storage Ponds (ISPs), one on each side of the pile. If water quality does not meet discharge requirements as identified in the Mine’s water licence, then the water will be directed from the ISPs to passive water treatment systems in the form of constructed wetlands. The wetlands are only required should water quality continue to require treatment prior to discharge into the environment.
De Beers’ two objectives for the closure of the North Pile are:

1. Prevent processed kimberlite from entering the surrounding terrestrial and aquatic environment.
2. Maintain a physically stable processed kimberlite containment area and limit risks that affect the safety of people or wildlife.

1.3.1.3 Site Infrastructure

As part of closure, buildings at the Snap Lake Mine will be fully decommissioned and removed. Non-hazardous materials will be disposed in the Mine’s landfill, hazardous materials will be disposed of off-site, and any contaminated soils will be treated or removed. Building areas, site roads (Figure 1.7), airstrip and pads will be revegetated or prepared to support natural revegetation.

De Beers’ three objectives for the closure of site infrastructure are to:

1. Prevent the remaining infrastructure from contaminating land or water.
2. Maintain on-site disposal areas that are safe for people, wildlife, and vegetation.
3. Establish contaminated soils and waste disposal areas that cannot contaminate land and water.
1.3.2 Post-Closure Phase

Environmental monitoring has been conducted at and near the Snap Lake Mine throughout its life. Continuing monitoring efforts through Closure and into the Post-Closure phase will allow De Beers to assess whether closure measures are performing as expected, and to make any changes necessary to meet closure goals and objectives.

Post-Closure monitoring will include the following programs:

- **Air Quality, Meteorology, and Emissions Monitoring**: to check that dust levels are safe for people, vegetation, aquatic life, and wildlife.
- **Geotechnical and Hydrological Monitoring**: to check that the mine components are physically stable, and that mine areas are safe for use by people and wildlife.
- **Surveillance Network and Aquatic Effects Monitoring**: to check that the Mine is not contaminating land or water, and that water quality is safe for people, vegetation, aquatic life, and wildlife.
- **Vegetation Monitoring**: to check that the shape and vegetation at the Mine site match the surrounding natural area and that revegetation (Figure 1.8) is occurring in priority areas.
- **Wildlife Effects Monitoring**: to check that Mine areas are physically stable and safe for use caribou and other wildlife.
De Beers expects that, after Closure, a minimum of ten years of Post-Closure monitoring will be required to ensure that all closure objectives have been reached. De Beers will submit reports showing that closure objectives have been achieved to the Mackenzie Valley Land and Water Board. De Beers may then return the land leases for the Snap Lake Mine to the Crown.

Figure 1.9 presents a schedule of all activities for closure of the Snap Lake Mine.

### 1.4 FCRP Organization

The Final Closure and Reclamation Plan document provides detailed information about all the topics presented in this summary. The reader is encouraged to obtain further information from the FCRP. The FCRP is organized according to guidance from the Mackenzie Valley Land and Water Board:

- Chapter 1 is this plain language summary of the FCRP.
- Chapter 2 provides the purpose and goal of the FCRP, introduces the closure and reclamation planning team, gives De Beers’ approach for community engagement, and summarizes the permits, authorizations and agreements that will be needed for closure and reclamation.
### Figure 1.9 Schedule of Closure Activities

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<td>Winder Road Construction</td>
<td>Year 0</td>
<td>Year 2</td>
<td>Year 2</td>
</tr>
<tr>
<td>Water Management System and North Pile Construction</td>
<td>Year 0</td>
<td>Year 3</td>
<td>Year 3</td>
</tr>
<tr>
<td>Passive Water Treatment System Commissioning</td>
<td>Year 0</td>
<td>Year 4</td>
<td>Year 4</td>
</tr>
<tr>
<td>Active Demolition</td>
<td>Year 0</td>
<td>Year 5</td>
<td>Year 5</td>
</tr>
<tr>
<td>Revegetation, Landforming, and Site Stabilization</td>
<td>Year 0</td>
<td>Year 6</td>
<td>Year 6</td>
</tr>
<tr>
<td>Post Closure Environmental Monitoring Programs</td>
<td>Year 0</td>
<td>Year 7</td>
<td>Year 7</td>
</tr>
</tbody>
</table>

*De Beers Group*
• Chapter 3 describes pre-disturbance and current conditions at the Mine with respect to the natural environment.
• Chapter 4 describes the Mine, including its location, access, site history, and site geology, and summarizes mining activities.
• Chapter 5 describes the plan for permanently closing the Mine, including closure objectives for each of the Mine’s components.
• Chapter 6 describes the plan for reclamation at the Mine site, including reclamation activities that are already complete.
• Chapter 7 is intended to describe Temporary Closure activities. This not applicable since the site is entering into Permanent Closure.
• Chapter 8 provides a schedule of closure activities.
• Chapter 9 explains how De Beers will assess the success of closure activities.
• Chapter 10 estimates the financial liability associated with permanently closing the Mine and summarizes the arrangements De Beers has made for the financial security of closure and reclamation planning.
• Chapter 11 provides a list of references used in the development of the FCRP.

Appendices include detailed engineering reports, assessments, and other supporting information used to develop the FCRP.
2. INTRODUCTION

The Snap Lake Mine (herein referred to as the Mine) is owned and operated by De Beers Canada Inc.

The Mine is located approximately 220 km northeast of Yellowknife, NWT, and is situated on a peninsula along the western shore of Snap Lake (see Figure 2.1). Kimberlite was discovered at the site in 1997 by Winspear Resources (Winspear). De Beers purchased the exploration project from Winspear in the fall of 2000 and obtained the necessary regulatory approvals in May 2004 to build and operate the Mine.

Production at the Mine began in 2008, with mining activities initially expected to extend until 2028 (De Beers, 2015a). Mining, however, was suspended in December 2015 and the Mine was placed into temporary closure, termed “Care and Maintenance”. In 2016 De Beers filed an extended Care and Maintenance (ECM) plan that was subsequently approved by the Mackenzie Valley Land and Water Board (MVLWB). In late 2017, De Beers announced its intent to enter into final Mine closure and to submit a Final Closure Reclamation Plan to the MVLWB in early 2019.

The Mine was an exclusively underground mining operation, targeting a diamond bearing kimberlite dyke that dips between 11 and 15 degrees to the northeast under Snap Lake and extends approximately 2.5 km east-west and 2 km north-south (De Beers, 2002). Major components of the constructed Mine include the underground mine workings (now flooded), as well as surface facilities including but not limited to: the North Pile facility for mine waste disposal, water management structures, water treatment facilities, bulk fuel storage facilities, roadways, an airstrip, laydown areas, and various buildings (i.e., processing plant complex, accommodations, warehouses and shops, etc.).

The kimberlite dyke was mined consistent with Workers’ Safety and Compensation Commission (WSCC) Mines Inspector approval which ensured the physical stability of the underground mine regardless of backfilling or flooding. The ore was then transferred to surface by conveyor, where it was processed on site. The diamond bearing host rock that was processed (kimberlite) and process water were disposed of on surface in the processed kimberlite disposal facility (North Pile). During operation, seepage water from the underground and runoff from the North Pile was collected in sumps, ponds and ditches, and transported via pipeline to the water treatment plant where it was treated to meet discharge quality criteria and released to Snap Lake. In 2017, in accordance with the approved ECM Plan and in consultation with the Government of the Northwest Territories Inspector, De Beers commenced flooding of the underground mine. The runoff from the North Pile continues to be collected, treated and released to Snap Lake and/or injected into the underground mine workings.

A general layout of the existing surface infrastructure is provided in Figure 2.2. Descriptions of each mine component are provided in Section 4.6.
Figure 2.1  Location of Snap Lake Mine, NWT

Source: De Beers (2018d)
Figure 2.2  Snap Lake Mine Layout

Source: De Beers (2019a)
2.1 Purpose and Scope of the Closure and Reclamation Plan

In the NWT, guidelines for closure and reclamation planning are outlined by the Mine Site Reclamation Policy for the Northwest Territories and the Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories prescribed by Indigenous and Northern Affairs Canada (INAC) and the Mackenzie Valley Land and Water Board (MVLWB), respectively. Concordance of the FCRP to these Guidelines is provided in Appendix B. Guidance for closure and reclamation cost estimate development is also outlined by the MVLWB under Guidelines for Closure and Reclamation Cost Estimates for Mines (2017).

Closure Reclamation Plans (CRPs) are updated throughout the life of the mine to advance closure planning from a conceptual plan to a final plan. Closure planning is not limited to the development of a CRP, but is a consideration in stakeholder engagement and many engineering designs for infrastructure, operation and maintenance activities, and monitoring throughout the life of mine.

This Final Closure Reclamation Plan (FCRP) is an update to the approved Interim Closure Reclamation Plan (ICRP version 3.2) and is intended to present a final plan to close and reclaim the site, based on current conditions at the Mine, the latest research on reclamation methods, and detailed engineering plans. The FCRP describes closure measures selected to take place during the Closure phase, such as decommissioning, demolition, landforming and revegetation activities, which will transition the site from active management to passive long term care. Post-Closure phase activities, including maintenance and monitoring programs devised to measure and ensure the successful long term closure of the site, are also described.

2.1.1 Previous Closure and Reclamation Plans

The closure and reclamation planning process for the Mine began during the environmental assessment and mine design stages. Early closure considerations evaluated possible residual effects from the site and incorporated mitigation measures within the design of the site. Each version of the ICRP has built upon the latest understanding of the environmental and operating conditions at the Mine site and continued reclamation research to further refine the closure and reclamation plan. This FCRP is aligned with the objectives of the previous ICRP, but includes additional information to advance the CRP from a conceptual plan to a detailed plan. The FCRP refines the closure criteria that will be used to confirm the achievement of closure objectives and incorporates these into the planning and design of closure measures. A key update to the measures proposed is the inclusion of a passive water treatment system, this is described further in Section 5.

A history of the closure planning process to date is summarized below:

- 2003 – Preliminary Mine Closure and Reclamation Plan (AMEC, 2003) submitted to the MVLWB in February 2003 during initial mine design work.
- 2011 – ICRP updated for submittal to the MVLWB as part of the De Beers water licence application package. MVLWB deferred the ICRP review and approval process until the following year.
2.1 2013 – Updated ICRP submitted to the MVLWB on July 29, 2013 (Arktis, 2013a) and approved January 30, 2014 (ICRP version 3.2).

2.2 2018 – On June 20, 2018 the MVLWB amended the ICRP condition in Permit MV2017D0032 to no longer require an updated ICRP and agreed to a target date of January 30, 2019 for DeBeers to submit the FCRP.

2.3 2019 – On January 17, 2019, the MVLWB extended the submission date for the FCRP to March 29, 2019.

2.2 Goal of the Closure and Reclamation Plan

The overarching goal for the Mine is to return the site, and affected areas around the Mine, to technically viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. This is consistent with the Guidelines, and has been the goal since project initiation.

The closure goal is supported by four closure principles: physical stability, chemical stability, no long-term active care requirements, and future use (including aesthetics and values). These closure principles guide the selection of closure objectives for each of the various mine components and guide the desired outcomes required of engineering studies. Descriptions of each closure principle are provided below. The closure objectives, and associated criteria, are presented in Section 5.2.3.

2.2.1 Physical Stability

Any project component that remains after closure will be constructed or modified at closure to be physically stable so that it does not exceedingly erode, subside, or shift from its intended position under natural extreme events or disruptive forces to which it may be subjected. Closure and reclamation is considered successful when physical structures are designed and constructed such that they do not pose a hazard to humans, wildlife, aquatic life, or environmental health and safety.

2.2.2 Chemical Stability

Any project component (including associated wastes) that remains at the Mine after closure will be chemically stable; chemical constituents released from the project components should not endanger human, wildlife, or environmental health and safety, and will not result in the inability to achieve appropriate water quality objectives in the receiving environment, and will not adversely affect long-term soil or air quality.

2.2.3 Post-Closure Active Care Requirements

As a primary goal, closure designs seek to achieve no active long term care and maintenance, ensuring that any project component that remains after Closure will not require long-term active care and maintenance. Post-Closure monitoring will be conducted for a defined period only. Physical and chemical stability will help ensure that this principle is achieved.
2.2.4  Future Land Use

The site should be compatible with the surrounding land and water bodies, wherever practical, once closure activities have been completed. Closure objectives have been developed to ensure that the Mine is returned to such a condition that:

- Naturally occurring bio-physical conditions, including any physical hazards in the area, are minimized;
- The Mine site is compatible, where possible, with the surrounding landscape at Closure;
- The closure condition of the Mine meets the intended level of land and aquatic function for Post-Closure;
- Local community values and culturally significant or unique attributes of the land are preserved in Post-Closure;
- The level and scale of environmental impacts are minimized to acceptable levels;
- The land use of surrounding areas prior to site development are protected; and
- The Mine supports the safe future use of the area by humans and wildlife.

2.3  Closure and Reclamation Planning Team

The De Beers project team consists of several levels of personnel, as shown in the organizational chart depicted in Figure 2.3. Closure and reclamation planning for Snap Lake is led by the Asset Retirement Department that includes a multi-disciplinary team to manage closure properties throughout its Canadian Operations. The Asset Retirement Department is led by the Asset Retirement Manager (Project Owner) who in turn reports to the DeBeers Canada Inc. (DBCI) Head of Sustainability.

The Steering Committee is comprised of senior (executive level) members from the De Beers Canada Calgary Support Center and provides overall direction to the Project Owners. An internal peer review team has been established by the Steering Committee to conduct period project audits against the Mine Closure Toolbox and the Company’s Investment Decision Process.

Figure 2.3  De Beers Project Team Organizational Chart

The DBCI Asset Retirement Manager and the Snap Lake Mine Closure Project Manager have established the Snap Lake Project Team, which is comprised of superintendent and team lead level positions in areas such as demolition, reclamation, environment, regulatory, and further supported by members of the core business functions from the Calgary Support Center including Human Resources, Finance, and Procurement.

Site services and maintenance personnel from the Snap Lake Extended Care and Maintenance contractors will provide execution support during the Closure phase when the main camp and site infrastructure are being demolished and site reclamation is undertaken. Where required, De Beers will contract third parties to provide technical support and to execute specific work packages.
For the preparation of the FCRP and related technical assessments, DeBeers has retained the services of third party specialists ERM Canada Consultants Ltd. (ERM), Golder Associates Ltd. (Golder), Deninu K’ue First Nation and Rowe’s Joint Venture (DKFN Rowe’s), and Arktis Solutions Inc. (Arktis). Closure and reclamation plans and associated engineering design have been developed with the support of this team. ERM assembled the FCRP from these plans, and in parallel undertook a third party review of the closure and reclamation plans, evaluating the alignment of these plans to closure objectives and establishing the measurable closure criteria. Figure 2.4 summarizes the roles of these parties in the various elements of the FCRP.

**Figure 2.4 Closure and Reclamation Planning Team**

![Diagram showing the roles of various parties in the closure and reclamation planning process.](image-url)
2.4 Engagement

2.4.1 Overview

De Beers has been, and continues to be, committed to engaging with Indigenous groups, communities and regulators throughout the life of the Mine. This includes consultation in relation to planning, construction, operation, and care-and-maintenance activities conducted to date, and in regard to the final closure of the Mine. Consultation related to closure began during the environmental assessment, continued through subsequent iterations of the ICRP (including technical workshops on closure and reclamation in 2011 and 2013), and has intensified since 2015 including the development of more detailed closure plans and criteria.

De Beers’ approach to engagement and planned engagement activities to date are described in the Snap Lake Mine Community Engagement Plan (De Beers, 2016a), which satisfies the engagement plan requirements of water licence MV2011L2-0004. This plan is inclusive of engagement during the care-and-maintenance phase in order to plan for closure of the Mine. Further engagement during the Closure Phase is described in the updated Community Engagement Plan (DeBeers, 2019b). The objectives of De Beers’ engagement activities during Closure are to:

- Enable an understanding of proposed care-and-maintenance and closure activities;
- Provide a forum for participants to ask questions, raise issues of concern, and provide feedback; and
- Strengthen relationships between De Beers and Indigenous communities and organizations.

As outlined in the Community Engagement Plan, De Beers’ approach to engagement is guided by principles of respect, transparency and trust:

- **Respect** for each party’s unique history, knowledge, perspective, and culture is the foundation of a positive relationship. Careful listening, understanding of communication protocols, and following through on commitments made are important ways of practicing respect.

- **Transparency** including complete disclosure of information, willingness to address issues as they arise, and willingness to adjust perspectives and practices as additional information is provided. Openness, sincerity, and honesty are core values necessary to genuine engagement.

- **Trust** between parties is recognized as vital to the success of engagement activities. Building trust requires a long-term commitment to the relationship and to following through on commitments. Engaging parties before, during, and after each stage or aspect of mine development helps to build and maintain trust.

De Beers’ engagement is planned and conducted alongside the consultative processes led by the MVLWB. De Beers’ regularly planned engagement includes annual visits to Indigenous communities to hold workshops and community meetings; site visits for community members to the mine; meetings with the Snap Lake Environmental Monitoring Agency (SLEMA) and Tłı̨cẖo Kwe Beh Working Group; and annual technical and/or traditional knowledge workshops coordinated through the SLEMA.
2.4.2 Scope

This summary focuses on engagement and consultation as related to closure and reclamation planning for the Snap Lake Mine, which builds on De Beers’ engagement over earlier phases. Records of past engagement are available in other documentation, including the Environmental Assessment Report (De Beers, 2002; for engagement activities undertaken in relation to the design and assessment of environmental and social impacts); water licence applications and renewals (including engagement updates); and annual closure and reclamation plan progress reports (including annual reports from 2012 to 2017, each of which contains a description of engagement and consultation related to closure plans, objectives, criteria, progressive reclamation, and related topics).

2.4.3 Indigenous Groups and Communities

The Snap Lake Mine is located on the shore of Snap Lake in the NWT. There are four Indigenous groups representing the primary communities potentially interested and/or affected by the Mine. These groups, and associated geographic communities, are summarized in Table 2.1 along with other Indigenous organizations and communities that have been engaged and consulted in regard to mine closure. Indigenous groups are consulted on the Mine through a number of forums, as described in Section 2.4.4, including community meetings and open houses, site visits, and other activities designed to solicit feedback and input from both community members and leaders.

Table 2.1 Indigenous Groups and Communities Engaged Regarding Closure

<table>
<thead>
<tr>
<th>Group / Organization</th>
<th>Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Indigenous Groups</strong></td>
<td></td>
</tr>
<tr>
<td>Tłįcho Government</td>
<td>Wekweëti, Gamëti, Whatì, and Behchokò</td>
</tr>
<tr>
<td>Lutsel K’e Dene First Nation (LKDFN)</td>
<td>Lutsel K’e</td>
</tr>
<tr>
<td>Yellowknives Dene First Nation (YKDFN)</td>
<td>Dettah and N’dillo</td>
</tr>
<tr>
<td>North Slave Métis Alliance (NSMA)</td>
<td>Based in Yellowknife, although members live throughout the North Slave region.</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
</tr>
<tr>
<td>Northwest Territories Métis Nation (NWTMN)</td>
<td>Hay River</td>
</tr>
<tr>
<td>Deninu Kué First Nation (DKFN)</td>
<td>Fort Resolution</td>
</tr>
</tbody>
</table>

2.4.4 Forums for Engagement

SLEMA

The Snap Lake Environmental Monitoring Agency (SLEMA) was established as a result of the Environmental Agreement between De Beers, Government of Canada, Government of NWT, and the IBA Indigenous groups (Tłįcho, LKDFN, YKDFN, and NSMA). The Agency provides independent monitoring and review for environmental management at the Mine.
The SLEMA Board was originally comprised of eight representatives from the four signatory Indigenous organization. Throughout Extended Care and Maintenance, SLEMA and De Beers have worked closely together to ensure that SLEMA was staffed consistent with the stage of mine life of Snap Lake. A goal of the SLEMA Board is to incorporate Indigenous knowledge and western science in its activities and recommendations, and this is supported by a Science Panel (including nominated experts with relevant subject matter expertise) and a Traditional Knowledge (TK) Panel (including Elders nominated by each Indigenous organization). Workshops are led by the SLEMA and supported by De Beers. SLEMA hosted TK Panel workshops focused on closure planning—and the integration of TK into closure planning and criteria—in November and December 2017 and in November 2018.

Snap Lake Working Group

The Snap Lake Working Group was established by the MVLWB in 2013 to facilitate information-sharing related to regulatory submissions and processes administered by the MVLWB. The working group is open to all affected parties. Participating groups are asked to maintain the same representatives to facilitate consistency in the discussions. In addition to De Beers and MVLWB, the working group typically includes representatives of the GWNT, federal government, the four IBA Indigenous groups, and the SLEMA. Through the working group, participating parties have regular opportunities to obtain information and updates, review submissions, and engage directly with MVLWB and De Beers.

Nine working group meetings have been held between 2013 and 2019. For each meeting, De Beers prepares a short presentation providing an update about the Mine; the presentation, agenda, and other relevant materials are shared in advance of the meeting. Meetings in February and May 2016, May 2017, and November 2018 focused on care and maintenance of the Mine and planning for closure. The most recent meeting (in March 2019) was held to further discuss technical details of the draft FCRP prior to submission.

Community Meetings

As part of annual engagement with Indigenous groups and communities, De Beers holds regular meetings in communities to provide information and updates about the project, and to seek feedback and answer questions from community members for each of the four IBA Indigenous groups. Community meetings in 2013, 2015, 2016, 2017, and 2018 included discussions about closure planning and closure criteria.

Traditional Knowledge Workshops

With support from De Beers, the SLEMA organizes TK workshops with Elders and other knowledge holders of the IBA Indigenous groups. The workshops are designed to engage participants in discussions about the Mine and specific topics of interest. Closure planning, objectives, and closure criteria have been topics of discussion in June 2015 and in November and December 2017. In 2018, TK workshops focussed on closure planning were held by the NSMA and the Tlicho Government (November 8, 2018; December 17-18, 2018). Through these workshops, TK has directly informed plans and designs for closure of the Mine site and the specification of closure criteria through discussions of what the site will look like after closure, ability of Indigenous people to access and use the land and traditional pursuits, and the importance of ecosystem services for environmental and cultural sustainability (Appendix C). De Beers considers these requirements to be an important part of the overall environmental, social and safety context for closure.
In addition to TK workshops, the annual fish tasting event at the mine site brings together Elders and other community representatives to fillet, taste, and evaluate freshly caught lake trout. The 2016 fish tasting event was the first event following the decision to put the Mine into a state of care and maintenance, and included discussion about ongoing environmental management and planning for closure. Fish tasting events were also held in 2017 and 2018 at the Mine.

**Site Visits**

De Beers welcomes representatives of Indigenous groups for pre-arranged visits to the Snap Lake Mine. Site visits typically include presentation of ongoing activities and recent updates, and a tour of the mine site. All four IBA Indigenous groups participated in site visits in the summer of 2015, including discussions about closure and reclamation planning. Following the transition to care and maintenance in December 2015, representatives of YKDFN visited the site in February 2016, and the annual fish-tasting event (involving all four Indigenous groups) was held at the site in September 2016.

**Closure Workshops**

In addition to dialogue about closure objectives and criteria within other engagement and updates, De Beers has facilitated closure-specific consultation through a series of workshops dedicated to the topic. Closure workshops were held in March 2013, May 2017, December 2017, November 2018, and March 2019. These forums have supported and informed the development of closure criteria for the ICRP and FCRP.

### 2.4.5 Record of Engagement

Table 2.2 summarizes consultation and engagement activities related to closure, with a focus on workshops, meetings, and other in-person engagement. A comprehensive consultation log detailing further engagement related to closure and reclamation is provided in Appendix C.

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2011</strong></td>
<td></td>
</tr>
<tr>
<td>Technical workshop: closure and reclamation (Yellowknife; May 4)</td>
<td>Discussed revision of ICRP to inform ICRP version 3.1 (submitted in 2011). Participants provided feedback on the structure and content of the ICRP, suggestions to strengthen goals and objectives, and suggestions supporting increased involvement of community representatives in closure planning.</td>
</tr>
</tbody>
</table>

<p>| <strong>2013</strong> | |
| Community meetings on closure and reclamation in January (Tlicho) and February (DKFN, LKDFN, and NSMA) | Community meetings included discussion about closure objectives, reclamation plans, and the ICRP. |
| Workshop: closure objectives (Yellowknife; Mar 13) | Proposed closure objectives were provided to stakeholders for review in advance of the workshop. Included discussion of closure options, closure objectives, and the proposed reclamation research plans. This workshop informed ICRP version 3.2 (submitted in 2013). |</p>
<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2015</strong></td>
<td></td>
</tr>
<tr>
<td>Community meetings in February (LKDFN) and June (NSMA, Gameti,</td>
<td>Included discussion of closure and reclamation as part of overall update.</td>
</tr>
<tr>
<td>Whati, Fort Resolution, and Behchoko)</td>
<td></td>
</tr>
<tr>
<td>Site visits in May (LKDFN), July (NSMA) and September (DKFN; YKDFN)</td>
<td>Included discussion of closure and reclamation as part of site tour.</td>
</tr>
<tr>
<td>TK workshop (SLEMA, Yellowknife; Jun 24-25)</td>
<td>Included discussion of closure and reclamation including revegetation. The TK Panel and SLEMA Board Members visited the Mine site, followed</td>
</tr>
<tr>
<td></td>
<td>by a workshop to discuss TK observations, comments, and questions.</td>
</tr>
<tr>
<td><strong>2016</strong></td>
<td></td>
</tr>
<tr>
<td>Community meetings in January (LKDFN), May (NWTMN; DKFN; YKDFN),</td>
<td>Community meetings included updates on care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td>June (NSMA), August (Tlicho), and December (Yellowknife; Edmonton)</td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>Meetings with Indigenous leaders in February (Tlicho), April (YKDFN),</td>
<td>Included updates and discussion of care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td>and May (YKDFN)</td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>Meeting with LKDFN Wildlife, Lands and Environment Committee (Lutsel</td>
<td>Included discussion of care and maintenance of the Mine, and closure planning.</td>
</tr>
<tr>
<td>K’e; Jan 21)</td>
<td></td>
</tr>
<tr>
<td>Meeting with Tlicho Kwe Beh working group (Yellowknife; Feb 4)</td>
<td>Included updates and discussion of care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td></td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>Snap Lake Working Group meeting (Yellowknife; Feb 15)</td>
<td>Included updates and discussion of care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td></td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>Site visit for YKDFN (Feb 25)</td>
<td>Full mine tour including discussion of care and maintenance.</td>
</tr>
<tr>
<td>SLEMA meeting (Yellowknife; May)</td>
<td>Included updates and discussion of care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td></td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>Snap Lake Working Group meeting (Yellowknife; May 5)</td>
<td>Included updates and discussion of care and maintenance of the Mine, long term planning for environmental management and monitoring, closure</td>
</tr>
<tr>
<td></td>
<td>plans, and closure criteria.</td>
</tr>
<tr>
<td>SLEMA meeting and open house (Lutsel K’e; Aug 29)</td>
<td>Status of care and maintenance, closure planning, and development of closure criteria.</td>
</tr>
<tr>
<td>Fish tasting event at mine site (Sep 4-5)</td>
<td>Annual fish tasting event including discussion of care and maintenance and plans for closure.</td>
</tr>
<tr>
<td>SLEMA annual general meeting (Yellowknife; Dec 14-15)</td>
<td>Update and discussion about the Mine and long-term regulatory processes.</td>
</tr>
</tbody>
</table>
## Event Description

### 2017

- **Closure workshop: Snap Lake Working Group (Yellowknife; May 30)**
  Included discussion of annual closure and reclamation plan progress report; research and engagement to inform the development of ICRP Version 4 including updated closure criteria.

- **Closure TK workshop: NSMA and SLEMA (Yellowknife; Nov 24)**
  Included discussion of TK inputs into closure planning and closure criteria.

- **Closure TK workshop: NSMA and SLEMA (Yellowknife; Dec 3)**
  Included discussion of traditional knowledge inputs into closure planning and closure criteria, with a focus on addressing TK questions regarding the proposed criteria.

- **Closure TK workshop: NSMA, LKDFN, Tlíchó, YKDFN, and SLEMA (Yellowknife; Dec 14)**
  Provided an update on the status of care and maintenance, and the closure and reclamation plan. Discussion included incorporation of TK into closure criteria.

- **Closure workshop: Snap Lake Working Group (Yellowknife)**
  Included discussion of closure objectives and proposed closure criteria to be included in the FCRP.

### 2018

- **YKDFN Chief Betsina and EA Melissa Mackenzie (N'Dilo July 31)**
  Discussion about Snap Lake remote monitoring, transition to zero occupancy and upcoming community meeting

- **YKDFN Community Meeting (N'Dilo July 31)**
  Snap Lake Update including discussion of Closure provided

- **SLEMA site visit to Snap Lake (Snap Lake Mine, July 13)**
  Snap Lake Update including transition to zero occupancy and closure, site tour

- **Fish tasting event at mine site (Snap Lake Mine, Aug 5-6)**
  Annual fish tasting event including discussion of care and maintenance and plans for closure.

- **Closure workshop: Snap Lake Working Group (Yellowknife; November 6)**
  Presentation and discussion of the planned closure activities, objectives, and criteria for the FCRP

- **Tlíchó Government Traditional Knowledge Workshop (Yellowknife, Nov.7)**
  Presentation and discussion of the planned closure activities, objectives, and criteria for the FCRP

### 2019

- **Closure workshop: Snap Lake Working Group (Yellowknife; March 7)**
  Included discussion of final closure and reclamation report; closure of the North Pile, water management systems, and Post-Closure monitoring programs.

### 2.5 Regulatory Instruments for Closure and Reclamation

Closure planning must consider requirements that are detailed within a wide variety of regulatory instruments such as: acts, regulations, policies, permits, authorizations, and agreements that are developed at Federal, Territorial government, and company-wide levels. A summary of the requirements applicable to the Mine during operations and closure are summarized in the following sections.
2.5.1 Guidelines and Policy

Beginning in the early 1980s, mining proponents were required to provide an Abandonment and Restoration Plan for approval as part of their applications for Water Licences and Land Leases. In 1990, Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories were drafted by the Northwest Territories Water Board and Department of Indigenous and Northern Affairs Canada (INAC) to provide a template for proponents and to standardize submitted reports. These guidelines were followed in 2002 by issuance of the Mine Site Reclamation Policy for the Northwest Territories (INAC, 2002) by INAC. The focus of the policy was to provide a foundation for the protection of the environment and disposition of liability related to mine closure in the NWT. In 2007, INAC introduced an updated version of the 1990 guidelines entitled Mine Site Reclamation Guidelines for the Northwest Territories (INAC, 2007) which were intended to complement the existing Mine Site Reclamation Policy. In 2013, the INAC and the land and water boards in the Mackenzie Valley developed the Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (referred to herein as the Guidelines) (MVLWB et al., 2013).

The overall preparation of this FRCP document was guided by three principal sources:


These sources provide a framework for the FRCP outline, and are a valuable source of information regarding appropriate level of detail, suggested content and general recommendations for successful closure planning. An additional resource utilized during preparation of this FRCP was the Mine Closure Toolbox, Version 2 (Anglo American, 2013). The toolbox informs De Beers’ obligations with regards to the development, evaluation and revision of mine closure plans.

The Sustainable Development Policy for mine closure states: “ensure each mine and facility has a decommissioning plan that addresses reducing long term environmental and community impacts, and that these plans are periodically updated together with provisions for implementation of the final costs of closure.” The Sustainable Development Policy also commits De Beers to the use of sustainable mining practices as detailed within the Towards Sustainable Mining (TSM) guiding principles and practices developed by the Mining Association of Canada (2013), which provide a framework for mine closure.
2.5.2 Licences, Permits, Authorizations, Agreements

De Beers holds several permits, authorizations and agreements, which it must adhere to with respect to both operational, and closure activities at the Mine. A list of the instruments most applicable to closure planning that are currently held, in addition to those that may be required for project development and closure, are presented in Table 2.3.

2.5.3 Conformance with Type A Water Licence Conditions

A tabular summary demonstrating how this FRCP satisfies the conditions of the Water Licence (MV2011L2-0004) is provided in Table 2.4. Implementation of this FRCP further satisfies the requirements of the Land Use Permit (MV2017D0032) through conformity to the Guidelines. A Type A water licence will be obtained for activities to occur during the Closure and Post-Closure phases.

2.5.4 Land Lease and Land Use Permit Requirements

The Snap Lake Mine operates within four Land Lease adjoining parcels administered by the Government of the Northwest Territories (GNWT), as well as under Land Use Permit MV2017D0032. A summary of the Land Lease and Land Use Permit requirements regarding closure, and how this FRCP satisfies their conditions is provided in Table 2.5. Except for the financial security requirement, the Land Lease and Land Use Permit requirements overlap with those outlined in the Water Licence (MV2011L2-0004). Financial security estimations are summarized in Section 10 of this document.
### Table 2.3  Permits, Licences and Authorizations Held by De Beers for the Snap Lake Mine

<table>
<thead>
<tr>
<th>Permits, Authorizations and Agreements</th>
<th>Mine Phase</th>
<th>Legislation</th>
<th>Agency</th>
<th>Expiry and Tenure</th>
</tr>
</thead>
</table>
| Land Leases: 75M/10-1-2, 75M/10-2-2, 75M/10-3-2, 75M/10-4-2 | Operations, Closure, and Post-Closure | Territorial Lands Act and Regulations | GNWT, Department of Lands | Expiry April 30, 2034  
Maximum 21 year lease for winter access road then renewal to cover final years. Renewal required in 2034  
Land leases required throughout closure and Post-Closure phases, until land can be relinquished to the Crown. |
Northwest Territories and Nunavut Mining Regulations | Mineral and Petroleum Resources Directorate, Indigenous and Northern Affairs Canada | Expiry Earliest January 11, 2021  
Initially issued from INAC for 21 years; renewable for a further 21 years. Mining lease renewal will be required for the purpose of completing earthworks during closure. Leased area may be minimized in Post-Closure. |
| Type A Water Licence MV2011L2-0004 | Operations, Closure, and Post-Closure | Northwest Territories Waters Act  
Northwest Territories Waters Regulations | Mackenzie Valley Land and Water Board | Expiry June 13, 2020  
To be renewed for additional years to reflect water management during the closure and Post-Closure phases (Licence tenure in renewals may be variable as dictated by the MVLWB). |
| Class A Land Use Permit MV2017D0032 | Operations, and Closure | Mackenzie Valley Resource Management Act  
Mackenzie Valley Land Use Regulations  
NWT Spill Contingency and Reporting Regulations  
Environmental Protection Act | Mackenzie Valley Land and Water Board (MVLWB) | End of Closure phase |
### Permits, Authorizations and Agreements

<table>
<thead>
<tr>
<th>Permits, Authorizations and Agreements</th>
<th>Mine Phase</th>
<th>Legislation</th>
<th>Agency</th>
<th>Expiry and Tenure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisheries Authorization no. SC00196 for the destruction of habitat associated with the following activities: 1. With respect to the construction of the water intake facility and the mine water outlet in Snap Lake. 2. With respect to the construction of a sedimentation pond berm and removal of water flow in Stream S29. 3. With respect to the zone of turbulence at the site of the treated effluent discharge.</td>
<td>Operations, and Closure</td>
<td>Fisheries Act</td>
<td>Fisheries and Oceans Canada, Fish Habitat Management</td>
<td>1. October 1, 2006 2. September 30, 2010 3. June 13, 2020 Further authorization needed at each stage of renewal of Water Licence or Land Use Permit, if fish habitat is harmfully altered, disrupted, destroyed. An extension to the authorization will be requested to capture the potential effects of closure activities on the zone of turbulence. Wetland discharge during the Post-Closure phase will not require continued Fisheries Authorization permitting.</td>
</tr>
<tr>
<td>Fisheries Authorization no. SC99123-A2¹ and SC00196-7.1¹ for temporary and permanent water intake for life of mine with monitoring and maintenance reporting</td>
<td>Operations, and Closure</td>
<td>Fisheries Act</td>
<td>Fisheries and Oceans Canada, Fish Habitat Management</td>
<td>End of Closure phase</td>
</tr>
<tr>
<td>Hazardous Waste Generation, Transport and Storage Permit NTG000166</td>
<td>Operations, and Closure</td>
<td>Mine Health Safety Act (Territorial)</td>
<td>GNWT, Chief Inspector, Workers Compensation Board</td>
<td>Long-term authorization needed for all phases of mine until closure is complete. Approval is granted at start of mine with annual review thereafter.</td>
</tr>
<tr>
<td>Explosives Storage, Explosives Handling, Magazine Permits Permit to Store Detonators Explosives Factory Licence</td>
<td>Operations, and Closure</td>
<td>Explosives Act and Regulations Mine Health and Safety Regulations (Territorial)</td>
<td>Department of Natural Resources Canada GNWT, Chief Inspector, Workers Compensation Board.</td>
<td>Long-term authorization needed for all phases of mine until closure is complete.</td>
</tr>
<tr>
<td>Permits, Authorizations and Agreements</td>
<td>Mine Phase</td>
<td>Legislation</td>
<td>Agency</td>
<td>Expiry and Tenure</td>
</tr>
<tr>
<td>---------------------------------------</td>
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<td>-------------</td>
<td>--------</td>
<td>------------------</td>
</tr>
<tr>
<td>Registration of Fuel Storage Tanks</td>
<td>Operations, and Closure</td>
<td>Environmental Protection Act</td>
<td>Environment Canada with cooperation from Indigenous and Northern Affairs Canada</td>
<td>Granted, no expiry indicated.</td>
</tr>
<tr>
<td>Approval to Transport Dangerous Goods</td>
<td>Operations, and Closure</td>
<td>Transportation of Dangerous Goods Act</td>
<td>Transport Canada</td>
<td>Long-term authorization needed for all phases of mine until closure is complete.</td>
</tr>
<tr>
<td>Operations and Safety Plan Approval</td>
<td>Operations, and Closure</td>
<td>Mine Health Safety Act (Territorial)</td>
<td>GNWT, Chief Inspector, Workers Compensation Board</td>
<td>Long-term authorization needed for all phases of mine until closure is complete. Approval is granted at start of mine with annual review thereafter.</td>
</tr>
<tr>
<td>Environmental Agreement</td>
<td>Operations, Closure and Post-Closure</td>
<td></td>
<td>Federal, Territorial and Tlicho governments, the North Slave Métis Alliance, Yellowknife Dene First Nation and Lutsel K’e Dene First Nation</td>
<td>Completion of all Closure and Reclamation activities, including Post-Closure monitoring, compliance and maintenance. A copy of the updated Environmental Management Plans, for the closure and Post-Closure phases of the project, must be provided to the Parties and Monitoring Agencies involved in the Agreement. The EMPs must include the FRCP, Spill Contingency, Emergency response, Water management, domestic and waste sewage, quarry, North Pile, air quality and emissions, and wildlife management.</td>
</tr>
</tbody>
</table>

1 De Beers has completed the habitat compensation for both Authorizations (SC99123 and SC00196) and associated reclamation activities as per Fisheries and Oceans Canada’s (DFO) No Net Loss Principle (DFO, 2013). The Fisheries Act Authorization SC00196 was amended in 2012 to reflect accepted fish habitat compensation, and to harmonize monitoring/reporting requirements with conditions of the Water Licence (MV2011L2-0004).
### Compliance status of Water Licence (MV2011L2-0004) Requirements

<table>
<thead>
<tr>
<th>Item in Water Licence</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part I – 1</td>
<td>The Licensee shall act in accordance with the approved Interim Closure and Reclamation Plan. Revisions to the Plan shall be submitted to the MVLWB, for approval, every three (3) years after the date of approval, or as directed by the MVLWB.</td>
<td>The Snap Lake Mine Final Closure and Reclamation Plan (FRCP) has been prepared using the Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB et al., 2013) as provided by the Mackenzie Valley Land and Water Board (MVLWB). Updated ICRPs have been submitted to the MVLWB in January 2006, April 2011, and July 2013.</td>
</tr>
<tr>
<td>Part I – 2</td>
<td>The Licensee shall submit to the MVLWB, by April 30 of the year following the calendar year reported, an Annual Closure and Reclamation Plan Progress Report. The Report shall be submitted for approval if changes are proposed to the Interim Closure and Reclamation Plan.</td>
<td>The Snap Lake Mine Annual Closure and Reclamation Plan Progress Report has been annually submitted to the MVLWB.</td>
</tr>
<tr>
<td>Part I – 1c</td>
<td>The Licensee shall, submit to the MVLWB, a minimum of twenty-four (24) months prior to the end of operations, for approval, a Final Closure and Reclamation Plan.</td>
<td>Snap Lake Mine suspended mine production on December 4, 2015, and is currently in a state of Extended Care and Maintenance. De Beers submitted to the MVLWB an ECM Plan describing planned activities at the site during temporary closure. De Beers provided notice on December 14, 2017 of their intention to transition Snap Lake Mine into Closure. This FCRP addresses the requirement of the ECM Plan to submit an updated closure reclamation plan.</td>
</tr>
<tr>
<td>Part I – 1d</td>
<td>The Licensee shall act in accordance with the approved Final Closure and Reclamation Plan and shall submit revisions to the Plan as directed by the MVLWB.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2.5: Compliance Status of Land Lease (75M/10-1-2, 75M/10-2-2, 75M/10-3-2, 75M/10-4-2) and Land Use Permit (MV2017D0032) Requirements

<table>
<thead>
<tr>
<th>Item in Land Lease or Land Use Permit</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Leases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 15</td>
<td>Within two years of the commencement date (April 30, 2004), submit a restoration plan (this term has since been replaced with CRP) to the Minister. The plan should be prepared with the objective of restoring the land as near as possible to its original state.</td>
<td>Following submission of a Preliminary Mine Closure and Reclamation Plan (AMEC, 2003) in 2003, the Snap Lake Mine Interim CRP (AMEC, 2006) was submitted to the MVLWB in January 2006 and approved May 31, 2006.</td>
</tr>
<tr>
<td>Item 16</td>
<td>Review and update the plan at the request of the Minister.</td>
<td>Updated ICRPs have been submitted to the MVLWB in January 2006, April 2011, and July 2013.</td>
</tr>
<tr>
<td>Item 21</td>
<td>A plan shall be submitted annually outlining the ongoing restoration completed in conformance with the approved plan of restoration, as well as, any variances to the plan.</td>
<td>The Snap Lake Mine Annual Closure and Reclamation Plan Progress Report is submitted annually to the MVLWB and GNWT.</td>
</tr>
<tr>
<td>Item 22a</td>
<td>Deposit and maintenance of financial security deposit.</td>
<td>All security required under the Type A Water Licence and Land Use Permits as well as the Environmental Agreement has been posted.</td>
</tr>
<tr>
<td><strong>Land Use Permit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part C - 71</td>
<td>The Permittee shall submit to the MVLWB for approval, by January 30, 2018, an Interim Closure and Reclamation Plan. Revisions to the Plan shall be submitted to the MVLWB, for approval, every 3 years after the date of approval, or as directed by the MVLWB.</td>
<td>The Snap Lake Mine Final Closure and Reclamation Plan (FRCP) has been prepared using the Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB et al., 2013) as provided by the MVLWB. Updated ICRPs have been submitted to the MVLWB in January 2006, April 2011, and July 2013.</td>
</tr>
</tbody>
</table>
3. PROJECT ENVIRONMENT

The following sections provide a description of the atmospheric, physical, chemical, and biological components of the Snap Lake Mine environment. The descriptions provide a brief summary of the baseline conditions characterized within the project Environmental Assessment Report (EAR) (De Beers, 2002). Where available, updates of the current site conditions, based on results of various follow-up studies and/or monitoring programs have been provided. It should be noted that the geographic extent of regional study areas (RSAs) and local study areas (LSAs) vary across the topics discussed within this section. Defined limits of the study areas, in addition to detail regarding the methodology and results of completed baseline studies, are described within the project EAR (De Beers, 2002).

3.1 Atmospheric Environment

3.1.1 Climate

Collection of meteorological data has been completed at the Mine since 1998, when site development for the Advanced Exploration Project began. From 1998 to 2001, meteorological data was collected from a temporary monitoring station located 1 km south of the water management pond (WMP), in support of the EAR (De Beers, 2002). At present, a meteorological station installed at the Mine site collects temperature, wind speed and direction, relative humidity, solar radiation and precipitation (rainfall) data. Identified as the ‘Hill Station’, it is located approximately 100 m south of the access road from the airstrip to the camp, near the height of land and west of the water management pond. There is a secondary weather station located at the communications building that can provide back-up data if the meteorological station fails.

A hydro-meteorological station is located at the shore of the northwest arm of Snap Lake. The ‘Lake Station’ measures lake weather conditions, including precipitation, wind speed and direction, air and water temperature, relative humidity, solar radiation and lake water level.

Meteorological data at the Mine is collected and reported annually within the Air Quality, Meteorological Monitoring and Emissions Report to the MVLWB as per the Water Licence MV2011L2-0004. Annual reporting requirements are outlined in the Air Quality and Emissions Monitoring and Management Plan. The location of the meteorological station is provided with the air quality monitoring location in Figure 3.1.

3.1.1.1 Temperature

The climate at the Mine is characterized by short, cool summers and long, cold winters. The surface air temperatures at the Mine from 2003 to 2017 are presented in Figure 3.2, with the 1981-2010 climate normal for Yellowknife provided for comparison (De Beers, 2018a). The temperature data indicate that average temperatures at the Mine and Yellowknife remain below freezing from October through April. Minimum monthly temperatures in Yellowknife from 1981 to 2010 are above 0 °C from June through September, while maximum monthly temperatures are above freezing from April through October.
During development of the EAR (De Beers, 2002), due to temporal limitations in the compiled air temperature dataset for Snap Lake area, synthetic temperature data were derived to provide a long-term weather record for use in activities such as numerical modeling of natural systems and engineering design. The synthetic temperature data derived for Snap Lake was compiled by averaging available data from Yellowknife A, Lupin and Contwoyto Lake monitoring sites from 1959 to 2001 (De Beers, 2002).

Based on the Mine site temperature data collected since 1998, the average temperatures observed at Snap Lake are generally within the range of the 30-year climate normal data for Yellowknife (Figure 3.2).

3.1.1.2 Precipitation

At the time of preparation for the project’s EAR (De Beers, 2002), no usable precipitation data was available from the on-site meteorological monitoring station. Therefore, the daily, monthly, and annual precipitation series for the Mine were inferred by adjusting the same data series from the Yellowknife A climate station (see EAR, De Beers, 2002). The resulting synthetic dataset was used in numerical modeling of natural systems and engineering design.
The monthly rainfall data for Snap Lake for 2004 to 2017 is presented below in Figure 3.3. For comparison, the 2004 to 2017 average monthly rainfall, the 2004 to 2017 average monthly precipitation (including snowfall) and the 1981 to 2010 rainfall normals for Yellowknife are also provided in Figure 3.3.

The total rainfall recorded at the Hill Station for Snap Lake in 2017 was 92.46 mm, which is approximately 40.8% lower than the Yellowknife total for 2017 (156.1 mm) and 45.9% lower than the Yellowknife long-term (1981 to 2010) annual rainfall average of 170.8 mm (De Beers, 2018a). The rain gauge at the Hill Station is not shielded, which could contribute to rainfall undercatch.

### 3.1.2 Air Quality

Air quality at the Mine is monitored as per the Air Quality and Emissions Monitoring and Management Plan. This includes particulate, dustfall and passive gas monitoring. A summary of the data is compiled and submitted annually with the Air Quality, Meteorological Monitoring and Emissions Report.

#### 3.1.2.1 Particulate Monitoring

Suspended particulate matter (fine dust) emissions can be generated by wind erosion of local landscapes, movement of vehicles/equipment, airstrip activities, construction activities, the combustion of diesel fuel, and solid waste incineration.
Figure 3.3  Average Monthly Rainfall Derived for Snap Lake and Yellowknife, Period of Record 2004 - 2017

Source: De Beers (2018a)

Initial monitoring of total suspended particulate (TSP, particles 30 micrometers and less) concentrations was completed from May 2000 to May 2001 to assess the baseline air quality at the Mine. The measured 24-hour TSP concentrations ranged from 1 to 148 µg/m³, with averages at each monitoring station of 39 µg/m³, 16 µg/m³, and 7 µg/m³, respectively, compared to the NWT 24-hour standard of 100 µg/m³ (De Beers, 2002). Monitoring of TSP continued through site development and mining operations; annual average concentrations from 2008 until 2015 are presented in Figure 3.4, with comparison to the NWT air quality standard and De Beers’ (2007) updated ambient air quality prediction.

By the end of 2015, all three TSP stations were also decommissioned. Monitoring for PM₁₀ (inhalable particulate matter) had also been undertaken at the airstrip and emulsion plant sites, but were decommissioned in July 2014, and replaced with PM₂.₅ (respirable particulate matter) monitors in November 2014 with approval from the GNWT.

At present, the PM₂.₅ particulate monitoring program continues with 24-hour average values sampled continuously during periods of camp occupancy at the monitoring location presented in Figure 3.1.
The time-weighted annual average PM$_{2.5}$ concentrations during active mining and C&M activities were consistently below the Northwest Territories (NWT) Ambient Air Quality Standards (AAQS) (see Figure 3.5), and have generally been similar to the 2007 Air Modelling Update prediction of 3 µg/m$^3$ PM$_{2.5}$ for ambient air during the mining phase, but excluding the active Mine area (De Beers, 2007).

### 3.1.2.2 Dustfall Monitoring

A part of baseline work completed during development of the EAR (De Beers, 2002), dustfall monitoring began in July 2001 to evaluate deposition during the ice free months. Results are reported in the Vegetation Monitoring Program (VMP) Annual Report. Average annual total dustfall was first reported for 2004 and 2005, measured as 158 and 48 mg/dm$^2$/30d, respectively.

The dustfall monitoring program measures the amount of fixed and total dustfall deposition occurring both on and off the Mine site. Currently, dustfall monitoring is completed at seven locations (see Figure 3.5). Two stations are located within the mine area: one north of the tankfarm and one west of the tankfarm. Five stations are located off-site: two south of the airstrip, one south of the emulsion plant, one on the north shore of Snap Lake, and one at the west end of Snap Lake. The on-site dustfall readings are compared to the Alberta industrial guideline of 158 mg/dm$^2$/30d (AESRD, 2016). The off-site data are compared to the more restrictive Alberta recreational guideline of 53 mg/dm$^2$/30d (AESRD, 2016). Comparisons to dustfall guidelines are made to identify the need to initiate mitigation measures and/or additional triggered monitoring or detailed studies as required. Triggered dustfall monitoring will help identify if dust from the Mine has caused a significant difference in plant species cover or composition of Ecological Land Classification (ELC) types, in the vigour of plant species, or in the depth of the active layer.
In 2017, the on-site total dustfall deposition rates were relatively low for all stations and only one of them exceeded the AAAQG. However, as outlined in the VMP, this event did not trigger additional monitoring or investigation (Arktis, 2019a).

These results cannot be used solely to assess whether dustfall is affecting vegetation communities. The Alberta dustfall guidance was developed in 1975 to address aesthetic concerns associated with elevated dustfall levels. There are no scientifically defensible relationships between these dustfall guidance documents and discernible effects on vegetation communities.

To assess if there is a linkage between dustfall and vegetation community composition and vigour, a 20 km dustfall transect was established in 2013, in a west-northwest direction away from the Mine based on prevailing winds. Total dustfall and fixed dustfall were sampled at nine monitoring locations positioned along the transect, as presented in Figure 3.6. Average dustfall deposition rates on the dustfall transect for 2013 were highest in July/August. Total dustfall measurements for off-site exceeded the AAQG for industrial areas at two locations, and fixed dustfall was exceeded at one location. Values ranged from 18.8 to 408 mg/100 dm$^2$/30d for total dustfall. Monitoring results were last reported for 2013 (Golder, 2014a). With the exception of the airstrip, the reference and exposure PSPs installed in 2004, 2005 and 2006 to support Triggered Monitoring Programs showed no signs of dust accumulation or impacts to vegetation in 2013.
Figure 3.6  Overview of Dustfall Monitoring Stations at the Snap Lake Mine

Source: Arktis (2019a)

Note: DFO10 decommissioned.
Dust accumulation was observed around the airstrip, particularly on the west end of site; however, signs or symptoms of stress were not observed on vegetation during qualitative assessments in 2013.

Vegetation dustfall monitoring is conducted every five years as per the VMP (Golder, 2014a), and was completed in 2018. The 2018 reporting will be available in Q1 2019 (Arktis, 2019a). Additional detail regarding VMP reporting is provided in Section 3.4.2.

### 3.1.2.3 Passive Gas Monitoring

Sulphur dioxide (SO\textsubscript{2}) and nitrogen dioxide (NO\textsubscript{2}) emissions are generated at the Mine by the combustion of diesel fuel (major sources include: power generation, motor vehicles/equipment operation and heat generation) and the incineration of solid waste. The passive gas monitoring program includes monthly sample collection for NO\textsubscript{2} and SO\textsubscript{2} at seven locations: four off-site and three on site. Sampling is conducted using “charged” cartridges containing material that is both reactive and selective to the target gases, as per the Air Quality and Emissions Monitoring and Management Plan.

Figure 3.7 and Figure 3.8 compare the concentrations of observed annual monitoring average concentrations, applicable regulatory standards and the Air Modeling Update Prediction (De Beers, 2007) for NO\textsubscript{2} and SO\textsubscript{2} from 2007 to 2017. Both NO\textsubscript{2} and SO\textsubscript{2} have exhibited low concentrations that were well below the comparative criteria and predicted values, and overall concentrations have decreased during care and maintenance, compared to the peak of mine development and operations in the late 2000s.

**Figure 3.7** Annual Average NO\textsubscript{2} Concentrations, 2007-2017

![Graph showing annual average NO\textsubscript{2} concentrations from 2006 to 2018](image)

Source: De Beers (2018a)
3.1.3 Air Emissions

Estimated emissions rates of greenhouse gas, fugitive dust, and combustion sources have been completed annually for the Mine site. Emission calculations were based on fuel consumption and emissions factors for the equipment at the Mine. Table 3.1 presents the estimated emissions rates at Snap Lake for 2006 to 2017. Table 3.2 presents the annual Snap Lake Greenhouse Gas Emissions estimates from 2005 to 2017. All emission rates are lower than those used in the EAR (De Beers, 2002) and in the Air Modelling Update Prediction (De Beers, 2007).

A comparison of emissions rates showed that the estimated emissions rates increased after the beginning of the mine operations phase in 2008 until 2011, likely due to overall increases in fuel consumption. From 2012 to 2015 emission totals were lower than those reported in 2011, despite overall increased fuel consumption. Emissions decreased due to three factors: fuel being used by equipment that had lower emission ratings, diesel instead of waste oil being used in some space heating furnaces, and refined emission factors used for calculating particulate matter for power generation.

Following the entry of the Mine into C&M in December 2015, air emissions have been significantly reduced compared to during active mining operations. Overall, the 2017 emissions rates were much lower than 2016. These differences were largely due to the reduced diesel fuel consumption in 2017 as well as the reduced volume of waste oil burned by the furnaces in 2017 during care and maintenance (De Beers, 2018a).
### Table 3.1  Estimated Emission Rates at Snap Lake from 2006 to 2017

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<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂ (t/d)</td>
<td>0.304</td>
<td>0.024</td>
<td>0.068</td>
<td>0.007</td>
<td>0.002</td>
<td>0.017</td>
<td>0.032</td>
<td>0.002</td>
<td>0.008</td>
<td>0.008</td>
<td>0.019</td>
<td>0.017</td>
<td>0.00042</td>
</tr>
<tr>
<td>NOₓ (t/d)</td>
<td>8.636</td>
<td>2.06</td>
<td>2.557</td>
<td>3.187</td>
<td>3.342</td>
<td>3.979</td>
<td>4.254</td>
<td>3.983</td>
<td>4.523</td>
<td>4.533</td>
<td>5.122</td>
<td>2.564</td>
<td>0.721</td>
</tr>
<tr>
<td>TSP (t/d)</td>
<td>0.325</td>
<td>0.071</td>
<td>0.084</td>
<td>0.110</td>
<td>0.108</td>
<td>0.132</td>
<td>0.145</td>
<td>0.100</td>
<td>0.111</td>
<td>0.112</td>
<td>0.117</td>
<td>0.059</td>
<td>0.017</td>
</tr>
<tr>
<td>PM₁₀ (t/d)</td>
<td>0.182</td>
<td>0.064</td>
<td>0.068</td>
<td>0.097</td>
<td>0.092</td>
<td>0.111</td>
<td>0.123</td>
<td>0.085</td>
<td>0.094</td>
<td>0.093</td>
<td>0.100</td>
<td>0.048</td>
<td>0.014</td>
</tr>
<tr>
<td>PM₂.₅ (t/d)</td>
<td>0.143</td>
<td>0.063</td>
<td>0.057</td>
<td>0.059</td>
<td>0.090</td>
<td>0.107</td>
<td>0.118</td>
<td>0.083</td>
<td>0.090</td>
<td>0.095</td>
<td>0.044</td>
<td>0.013</td>
<td></td>
</tr>
</tbody>
</table>

Source: De Beers (2018a)

* (De Beers, 2007)

Notes:

* Emission rates based on 2013-2015 ratios due to the 2016 and 2017 source breakdowns being unavailable, with the exception of the fleet totals.

SO₂ = sulphur dioxide; NOₓ = oxides of nitrogen; TSP = Total Suspended Particulate; PM₁₀ = particulate matter nominally less than or equal to 10 micrometres aerodynamic diameter; PM₂.₅ = particulate matter nominally less than or equal to 2.5 micrometres aerodynamic diameter; t/d = tonnes/day.

### Table 3.2  Annual Snap Lake Greenhouse Gas Emission Comparisons, 2005 to 2017

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ (kt/yr)</td>
<td>24.72</td>
<td>44.13</td>
<td>49.11</td>
<td>55.35</td>
<td>65.13</td>
<td>76.95</td>
<td>82.75</td>
<td>84.60</td>
<td>98.83</td>
<td>100.52</td>
<td>116.24</td>
<td>56.84</td>
<td>15.78</td>
</tr>
<tr>
<td>CH₄ (kt/yr)</td>
<td>0.03</td>
<td>0.05</td>
<td>0.05</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.003</td>
<td>0.001</td>
</tr>
<tr>
<td>N₂O (kt/yr)</td>
<td>1.12</td>
<td>2.00</td>
<td>2.23</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.009</td>
<td>0.003</td>
</tr>
<tr>
<td>Total CO₂e (kt/yr)</td>
<td>25.87</td>
<td>46.18</td>
<td>51.39</td>
<td>62.51</td>
<td>68.23</td>
<td>80.61</td>
<td>86.68</td>
<td>88.63</td>
<td>103.38</td>
<td>105.15</td>
<td>122.28</td>
<td>59.55</td>
<td>16.63</td>
</tr>
</tbody>
</table>

Source: De Beers (2018a)

kt/yr = kilotonnes per year; CO₂ = carbon dioxide; CH₄ = methane; N₂O = nitrous oxide; CO₂e = carbon dioxide equivalent.
3.2  Physical Environment

3.2.1  Topography and Surface Hydrology

The topography of the northwest peninsula of Snap Lake, where the Mine is located, can be described as gently sloping, with low relief and occasional bedrock knolls (Figure 3.9). Surface elevations vary from just less than 445 metres above sea level (masl) at the Snap Lake lakeshore to approximately 482 masl on a knoll immediately southwest of the water management pond (WMP). Some low-lying areas of peat and organic soils are found on the northern part of the peninsula. Large scattered boulders and frost-shattered rocks dominate the ground.

The mine site is within the Sub-Arctic Precambrian Shield hydrologic region, which extends in a narrow band across the northeast end of Great Slave Lake and trends northwest to, and including, Great Bear Lake. Snap Lake is a headwater lake with drainage area of approximately 67.5 km$^2$. The outflow from Snap Lake travels over approximately 38 km through a series of small lakes, prior to discharging to MacKay Lake. Over this distance, inflows from several drainages combine and drain an area of 1,367 km$^2$ to MacKay Lake. MacKay Lake is part of the Lockhart River system that flows east and then southwest before discharging to Great Slave Lake, which is part of the Mackenzie River drainage area. In total, the Lockhart River drains an area of approximately 27,000 km$^2$ (Figure 3.10) (Golder, 2017a).

Numerous small streams ranging from less than 100 meters to several kilometers in length provide local drainage to Snap Lake. Figure 3.11 indicates the boundaries and the size of internal sub-basins. Outflow from Snap Lake exits the east arm of the lake through two sub-parallel channels. These channels flow for approximately 300 m prior to discharging to a small lake.

Within the Snap Lake drainage area, the terrain type consists of lakes and ponds (35%), wetlands (4%), and uplands (61%) (De Beers, 2002). The maximum elevation within the watershed is approximately 482 masl at the Mine site, while the lowest point is the Snap Lake surface elevation at approximately 444 masl. The largest sub-basin contributing flows to Snap Lake is about 700 ha while the smallest sub-basins drain several hectares. In general, drainage paths are not well defined. Runoff from upland areas tends to collect in small ponds and muskeg areas, passing downslope when accumulations exceed the capacity of the ponded area.

As a result of mining operations, water levels were predicted by the EAR (De Beers, 2002) to increase above baseline lake elevations in Snap Lake by 53 mm in year 6 of mining, and decrease below the baseline in Northeast Lake by 16 mm and in North Lake by 30 mm. Although it would be difficult to differentiate these predicted changes from the natural seasonal lake water elevation fluctuations that result from precipitation, evaporation, and other environmental factors, the water levels at Snap Lake, the 1999 Reference Lake, North Lake, and Northeast Lake (see Figure 3.19 for locations) were surveyed three times annually on approximately the same date from 2002 to 2017.

A graphical presentation of the changes in surveyed water elevations for each lake relative to their September 2005 baseline elevations is shown in Figure 3.12. Fluctuations in Snap Lake water levels are similar to those of the other surveyed lakes and the predicted changes in Snap Lake water levels due to mining activity were not observed (De Beers, 2018b).
Figure 3.9   Topographic Map of Snap Lake Mine

Source: NRC Toporama (2018a)

Note: National Topographic System (NTS) 075M10, with Universal Transverse Mercator (UTM) 1 km grid.
Figure 3.10  Snap Lake Drainage System to Great Slave Lake

Source: Golder (2017a)
Figure 3.11  Snap Lake Watershed and Sub-watershed Boundaries

Source: De Beers (2002)
Figure 3.12  Surveyed Water Elevations from 2005 to 2017 for Selected Lakes near the Snap Lake Mine

Source: De Beers (2018b)

3.2.2 Surficial Geology

The Project area is described as a rolling boulder plain (Rampton, V.N and Sharpe, D. R., 2014); however, there is little published information on the local surficial geology. Based on aerial photograph review, site reconnaissance observations, and test pit and borehole information, the surficial geology of the area consists of a veneer of Quaternary morainal deposits (till) that contain cobbles and boulders mixed with a finer-grained matrix of sand and silt with some gravel. The till is generally thin (generally less than 2 m thick) and discontinuous, but can be thicker (one observation of a 6 m thickness was made) in topographic depressions. Dystric brunisols are the dominant soil type. At sites with near-surface permafrost, the soils consist of turbic cryosols and organic cryosols. These permafrost features occur in poorly drained, thicker peat-filled depressions throughout the vicinity of the Mine site, and are discontinuous with low ice content and scattered ice wedges.

Fields of boulders, felsenmeer (i.e., a veneer of large angular blocks of rock), and shattered rock debris are also found in topographic depressions. Bedrock outcrops are common. Occasionally there are other types of unconsolidated deposits, including possibly lacustrine deposits along the lakeshore and various organic deposits. In fine grained, saturated or organic deposits, the effects of frost action can be observed and the materials appeared cryoturbated (i.e., disturbed by frost action) on aerial photographs.
3.2.3 Geology

The Mine is located in the Slave Geological Province, which is comprised of interspersed Archean granitoid intrusions, supracrustal sequences, and basement core complexes (Padgham and Fyson, 1992).

The geologic setting of the Mine site is presented in Figure 3.13. The regional bedrock geology consists of Archean granitic rocks, overlain locally by relatively small bodies of metavolcanic rocks. The metavolcanic rocks are crosscut by diabase dykes and sills of Proterozoic age. Diamond-bearing kimberlite ore occurs as a dyke that averages 2 to 3 metres (m) in true thickness. The Snap Lake kimberlite dyke subcrops on the northwest peninsula and dips shallowly below the lake, to the northeast.

The kimberlite contains a significant amount of carbonates (3 to 5 wt.%), which occur as calcite and dolomite, while sulphides are rare (LRC 1999a,b; LRC 2000a,b; LRC 2001).

Metavolcanic rock hosts the kimberlite dyke near the northwest peninsula. The metavolcanics consist mainly of well-foliated, high-grade amphibolites. Within the metavolcanic unit, a small amount of pyrite and pyrrhotite, and less commonly chalcopyrite and other sulphides, is locally concentrated in layer-parallel zones. Metavolcanic rocks host localized concentrations of sulphide minerals, including pyrite and pyrrhotite, with rare chalcopyrite, in layer parallel zones (De Beers, 2002). The metavolcanic unit surfaces over much of the northwest peninsula (i.e., from west of the kimberlite subcrop to below Snap Lake).

Intrusive granitic rock hosts the kimberlite dyke at distances greater than 300 m from the northwest peninsula. Intrusive rocks at the Mine are characterized as a multiphase granitoid. Biotite ± hornblende granodiorite, granite, and tonalite are the dominant phases of the bulk of the intrusive granitoids, and muscovite-bearing pegmatite or granitic dykes transect each. Granitic material is also present as layers and intrusions within the metavolcanics of the northwest peninsula, with margins between the granite and the metavolcanics often filled with sulphide-bearing veins.

The major structures in the area are two east-west trending, roughly vertically-oriented faults: the Snap Fault and the Crackle Fault (Figure 3.13). The surface expression of these faults is characterized by quartz-hematite (iron oxide) veining. Intersecting the Snap Fault is an unnamed north-south trending fault that divides a granodiorite (i.e., granite/quartz) granite assemblage to the west and metavolcanic rocks to the east.

3.2.4 Geological Hazards and Seismicity

Geological hazards include landslides, mudflows, debris flows, rock slides and earthquakes. Slides and flows can occur in the Slave Geological Province depending on topography, particularly if the permafrost has been disturbed, although these events are not generally associated with the gently sloping topography in the vicinity of the Mine.

Figure 3.14 shows historical earthquake activity in or near Canada, provided by Natural Resources Canada (NRC, 2018). There are no historical, potentially damaging (>5 magnitude) seismic events recorded within 500 km of the site.
Figure 3.13  Geologic map in the vicinity of the Snap Lake Mine

Source: Golder (2015)
The Mine is located within Seismic Zone 0 of the current National Building Code (NRCES, 2010), which is the zone characterized to have the lowest seismic hazard. Based on information obtained from the Pacific Geoscience Centre, the peak horizontal ground acceleration for the Mine for an event having a risk of exceedance of 10 percent in 50 years (equivalent to a 475-year return period) is 0.013 g (Table 3.3).

In other words, in the event of a 475-year return period earthquake occurring in the area of the Mine, the maximum acceleration at which the ground surface would shake along the horizontal direction is equivalent to slightly over one percent of gravity or 0.013 g. The Pacific Geoscience Centre gives the peak horizontal ground velocity for this event as 0.039 m/s.
Table 3.3  Seismic Risk Data for the Mine

<table>
<thead>
<tr>
<th>Probability of Exceedance per Annum (%)</th>
<th>Probability of Exceedance in 50 years (%)</th>
<th>Peak Horizontal Ground Acceleration (g)</th>
<th>Peak Horizontal Ground Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>40</td>
<td>0.009</td>
<td>0.027</td>
</tr>
<tr>
<td>0.005</td>
<td>22</td>
<td>0.011</td>
<td>0.032</td>
</tr>
<tr>
<td>0.002</td>
<td>10</td>
<td>0.013</td>
<td>0.039</td>
</tr>
<tr>
<td>0.001</td>
<td>5</td>
<td>0.016</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Notes:
  
g = gravity


3.2.5  Permafrost

The Mine site is located just north of the border between zones of discontinuous and continuous permafrost, based on information provided by the International Permafrost Association (Golder, 2000). The Atlas of Canada Permafrost Map (NRC, 1995) gives a permafrost and ground ice classification symbol of ‘Cl’ for the Snap Lake Mine. This classification means that approximately 90% to 100% of the land area is underlain by permafrost, and that the ground ice content (% by volume of visible ice) in the upper 10 m to 20 m is low (<10%). This includes segregated ice, intrusive ice, reticulate ice veins, ice crystals and ice coatings on soil particles.

Thermal monitoring results acquired in support of the Advanced Exploration Program (AEP) between 1999 and 2002 (De Beers, 2002), confirmed the site to be situated within an area of continuous permafrost; however, proximity to Snap Lake has a substantial effect on its distribution. A talik zone extends laterally and vertically from the lake. Laterally, thermistor data indicated that the talik exists up to 20 m to 40 m back from the shoreline of Snap Lake. Most of the Mine facilities are located on continuous permafrost, although a portion of Dam 1 (at the south end of the water management pond) is located within a talik zone suspected to be a result of a natural pond at that location that outflows towards Snap Lake (De Beers, 2002).

A thermistor angled below Snap Lake from near the peninsula shoreline identified permafrost conditions to approximately 28 m vertically below ground surface, warming up below that depth (De Beers, 2002). There are two frozen/unfrozen interfaces in the underground mine. The portal is located at surface within the active layer that freezes and thaws annually to a depth of approximately 7 m below ground surface on the northwest peninsula. The ramp continues downwards through permafrost until the second interface is reached near the shoreline of Snap Lake. From the shore onwards the mine development is under the lake and in the talik zone, which is unfrozen. During development of the ramp, and geotechnical investigations completed in the areas of the mill and ancillary facilities, no massive ground ice was encountered (De Beers, 2002).

Pre-development thermal monitoring at locations more than 50 m from the Snap Lake shoreline indicate that the active layer has a thickness ranging from 5 m to 7 m at most locations (except the airstrip), depending on soil/rock conditions. The depth of zero annual amplitude, with ground temperatures in the range of -1.3 °C to about -2 °C, was projected to be between 15 and 20 m below ground surface.
Permafrost was not encountered within 8 m of the ground surface during the initial investigation at the airstrip, which is at a higher elevation than other areas of the Mine site (De Beers, 2002). This result suggests that there is a topographic control on the depth to permafrost.

In addition to thermal monitoring locations from the AEP, additional thermistors were installed at the Project site, with a focus at the North Pile and WMP dam areas. Thermistor locations are shown in Figure 3.15. A summary report of the 2017 thermal monitoring data was completed by Arktis (2018b); key conclusions include:

**North Pile Perimeter Thermistors**
- There are no indications that the North Pile development has affected the permafrost regime outside its direct footprint.
- The active layer thickness generally ranges between 0 m and 15.5 m surrounding the North Pile and in the vicinity of the undeveloped West Cell.
- Thermistors located north towards the shoreline of Snap Lake (TH08-03, 04, 08, 10, and 13) indicated an active layer thickness of 2.0 to 5.1 m in both 2016 and 2017. The potential presence of a talik is indicated at thermistor locations TH08-08, TH08-10 and TH13-02.
- The permafrost depth is extrapolated to approximately 200 m at TH13-05, since installation in 2013, which is installed south of the North Pile to a depth of 150 m below ground surface.

**West Cell Thermistors**
- Data indicate an active layer thickness of about 4.4 m to 19.5 m; however, thermistors TH14-13, TH14-11, TH14-09, TH14-06, TH14-02, and TH14-01 are likely still equilibrating as indicated by fluctuating temperature profiles.

**Starter Cell Thermistors**
- Following the start of deposition activities in 2007/2008, deposited materials insulated the underlying ground and dampened the temperature fluctuations, as expected.
- There is aggradation of permafrost towards the original ground surface and into the deposited materials for several thermistors. Cryotic ground is also observed at 4.1 m depth within subcell F. This indicates that the deposited materials are freezing.
- Permafrost has been identified at a depth of 4.6 m at instrument TH13-01 installed within the southwest embankment of the Starter Cell.

**East Cell Thermistors**
- Following the start of deposition activities in 2011/2012, deposited materials insulated the underlying ground and dampened the temperature fluctuations, as expected.
- There is aggradation of permafrost towards the original ground surface and into the overlying North Pile embankment. This indicates that the deposited materials are freezing.
- Data indicate an active layer thickness of about 3.7 m to 18.6 m within the East Cell embankments.
Figure 3.15  Site Plan showing Thermistor Locations

Source: Arktis (2018a; modified from Golder, 2016a)
Water Management Pond

- The thermistors within and in close proximity to the WMP dams show that the foundations are thawed to marginally frozen throughout the year, as is expected due to the effect of the WMP forming a talik beneath it. Thermal conditions have remained consistent since the start of monitoring in 2000. It is noted that this observation is consistent with the EAR (De Beers, 2002) interpretation of a talik local to this area.

Snap Lake Shoreline

- No cryotic ground or permafrost was observed at thermistors installed along the northwest peninsula shoreline of Snap Lake, which may be due to a talik beneath Snap Lake.

In general, in 2017, the ground thermal conditions and trends at the North Pile and water management pond were consistent with previous years (during operations into ECM), and no notable changes were observed throughout 2017 (Arktis, 2018a).

3.2.6 Hydrogeology

The hydrogeological setting at the Mine is characterized by its location adjacent a headwater lake, just north of the border between the zone of discontinuous and continuous permafrost. A talik exists beneath Snap Lake, with permafrost becoming thicker with distance from the lake. Permafrost conditions are discussed in Section 3.2.5.

Snap Lake is a headwater lake; the water level in the lake is the highest of the lakes within the Regional Study Area (RSA). The water elevations of the lakes near Snap Lake and the inferred deep groundwater flow directions are presented in Figure 3.16. Groundwater is expected to flow radially away from Snap Lake with inferred hydraulic gradients ranging from approximately 0.001 to 0.004, and an average gradient of approximately 0.002.

Two groundwater flow regimes have been characterized at the project site: a shallow groundwater flow regime within the active layer and a deep groundwater flow regime located beneath the permafrost and within the talik of large water bodies. Permafrost commonly reduces the hydraulic conductivity of the rock by one to two orders of magnitude (Anderson, D.M., and N.R. Morgenstern, 1973; Burt, T.P., and P.J. Williams, 1976). Consequently, the permafrost in the rock underlying the northwest peninsula would effectively provide little to no hydraulic connection between shallow groundwater in the active layer and the deep groundwater regime located below the deep permafrost; however, Snap Lake and its talik provides hydraulic connectivity between the shallow and deep groundwater regimes.

A conceptual hydrogeological model for the underground mine was prepared by Itasca, and most recently updated in 2016. For the purpose of modeling groundwater flow, Itasca (2016) characterized the following hydrostratigraphic units under Snap Lake:

1. Lakebed Sediments – This unit is a relatively thin veneer of till, possible glacial outwash, and post-glacial organic materials on the bottom of Snap Lake. In the model, a two-metre thick lakebed sediments layer is considered to be less permeable than the underlying exfoliation zone.
Figure 3.16  Surface Elevations of Area Lakes and Inferred Regional Groundwater Flow Directions

Source: De Beers (2002)
2. **Exfoliation Zone** – This unit is the uppermost portion of the crystalline bedrock, where post-glacial unloading has resulted in tensile fractures, primarily with horizontal orientation. This zone is set to be more permeable than the deeper bedrock.

3. **Permafrost** – This unit consists of the soil at or below the freezing point of water over time. It is a low-permeable unit with a thickness of up to 210 metres below ground surface (mbgs).

4. **Bedrock Unit Above Dyke** – This unit includes all of the bedrock below the exfoliation zone (or permafrost below the land) and above the kimberlite dyke. The hydraulic conductivity (K) value of this unit is assumed to decrease with depth.

5. **Kimberlite Dyke** – The kimberlite dyke layer is generally less than four metres thick and has a relatively low K value.

6. **Bedrock Unit Below Dyke** – This unit is comprised of a massive bedrock or country rock unit beneath the kimberlite. Its K value is considered to decrease with depth.

On the northwest peninsula of Snap Lake, the hydraulic conductivity of the weathered rock underlying the till was found to be approximately $1 \times 10^{-5}$ m/s. This is underlain, at roughly 8 m depth, by competent bedrock with a measured hydraulic conductivity of less than $3 \times 10^{-8}$ m/s (De Beers, 2002). Within the active layer, shallow groundwater flow is towards local depressions and ponds that drain to Snap Lake or directly to Snap Lake. The active layer at surface has been observed to range from near 0 m to 16 m in thickness in areas unaffected by North Pile operations.

In 2012, 2013, 2015, and 2016, De Beers updated the groundwater flow model and TDS calculations for the Mine (Itasca, 2012, 2013, 2015, 2016). For each update, refinement of the model was completed using monitoring data compiled from a variety of sources. Groundwater inflow rates and TDS concentrations were monitored within the underground mine workings from the beginning of mine operations until the mine was allowed to flood in 2017. Geologic data also collected during operation of the underground mine has provided a comprehensive geologic delineation of faults in the mine area, which typically influence hydraulic conductivities of the rock units present. Various hydraulic tests (e.g., slug tests, packer test) were also conducted from 2005 to 2012.

The 2015 model predicted a total seepage rate that closely matched the measured seepage based on mine dewatering rates of approximately 45,000 m$^3$/day in Q1 of 2015 (Figure 3.17; Itasca, 2015). The model concluded that the main source of seepage to the mine was Snap Lake, and also predicted that the maximum seepage from the lower part of the footwall, which contributed to elevated TDS (refer to Section 3.3.3), would represent approximately 7,000 m$^3$/day in 2015.

The latest model update (Itasca, 2016) was conducted for mine discharge under eight scenarios of care and maintenance conditions, related to different flood elevations of the mine workings after the cessation of mining in December 2015. The model included a scenario for allowing the groundwater to recover to its maximum level in the mine workings, predicted to require 222 days (with 30% uncertainty), which was subsequently implemented in 2017.

In 2016, prior to the flooding of the mine, mine water discharge rates varied from 20,986 to 56,997 m$^3$/day during the 2016 monitoring period.
Figure 3.17 Underground Mine Measured and Predicted Seepage Rates for 2004-2015

Source: Itasca (2015)

Note: Purple squares = measured total seepage rate; blue triangles = simulated total seepage rate; green triangles = simulated footwall seepage.

3.3 Chemical Environment

3.3.1 Overburden and Soil Chemistry

During the EA (De Beers, 2002), soil samples were collected from the Regional Study Area (RSA) and mean concentrations of metals and PAHs were calculated to represent baseline concentrations. The completed tabulated baseline groundwater quality results are presented within the EAR. A summary of the mean concentrations of baseline soil analyses is provided in Table 3.4. The Canadian Council of Ministers of the Environment (CCME) (1999) Canadian Soil Quality Guidelines for agricultural land use provided for comparative purposes; the mean soil concentrations meet the comparative guideline values for all parameters assessed.

3.3.2 Acid Rock Drainage and Metal Leaching Potential

A detailed geochemical evaluation was completed in support of the EAR between June 1999 and October 2001. The objective of the EAR geochemistry program was to evaluate the acid rock drainage (ARD) potential of rock at the Mine, and to evaluate the potential for metal leaching under acid generating, neutral, and alkaline conditions. The EAR geochemistry program was developed according to the guidelines in Indigenous and Northern Affairs Canada (INAC; 1992) and Price (1997), and included the characterization
of over 300 samples of kimberlite, metavolcanic, and granitic rock from boreholes and surface materials. The geochemical characterization took into account the spatial distribution of materials across the Mine site. Detailed results are provided in Appendix III.2 of the EAR (De Beers, 2002).

### Table 3.4 Baseline Soil Quality Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>CCME Agricultural (a)</th>
<th>Soil Baseline (mean) (b)</th>
<th>Parameter</th>
<th>Units</th>
<th>CCME Agricultural (a)</th>
<th>Soil Baseline (mean) (b)</th>
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<td>Manganese</td>
<td>μg/g</td>
<td>4,000e</td>
<td>109</td>
<td>Benzo(k)fluoranthene</td>
<td>μg/g</td>
<td>6.2</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Mercury</td>
<td>μg/g</td>
<td>6.6</td>
<td>0.05</td>
<td>Dibenzo(ah)anthracene</td>
<td>μg/g</td>
<td>0.1</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>μg/g</td>
<td>5</td>
<td>1.8</td>
<td>Indeno(1,2,3-cd)pyrene</td>
<td>μg/g</td>
<td>0.1</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Nickel</td>
<td>μg/g</td>
<td>45</td>
<td>21.8</td>
<td>Naphthalene</td>
<td>μg/g</td>
<td>8.8</td>
<td>0.07</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>μg/g</td>
<td>-</td>
<td>396</td>
<td>Pyrene</td>
<td>μg/g</td>
<td>7.7</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Potassium</td>
<td>μg/g</td>
<td>-</td>
<td>2,182</td>
<td>Quinoline</td>
<td>μg/g</td>
<td>0.1</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Source: modified from Arktis (2017a)

Notes:

- CCME, 1999c. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (with updates to 2015).*
The following principal conclusions regarding the potential for acid rock drainage and metal leaching potential were drawn from the geochemical baseline program:

- Snap Lake kimberlite is non-potentially acid generating (non-PAG) due to its low sulphide sulphur content and substantial excess neutralization potential.

- Runoff or leachate from processed kimberlite (PK) will be neutral or slightly alkaline, and contain low metal concentrations.

- Granite with no visible sulphides (e.g., pyrite and/or pyrrhotite) is non-PAG due to its low sulphur content. Mixtures of metavolcanics and granites located in the vicinity of the metavolcanic unit that contains sulphur in excess of 0.3 percent by weight (wt%) should be classified as PAG. Granite that does not contain extensive fracturing and/or is located away from the metavolcanic unit is non-PAG, and is appropriate for use in construction.

- Runoff or discharge from excavated granite used in construction or as cover will be neutral and contain low metal concentrations.

- Metavolcanic material with a sulphur concentration in excess of 0.3 wt% is considered PAG.

- Grain size reduction of metavolcanic rocks appears to reduce the likelihood of acid generation relative to the bulk material due to enhanced exposure of carbonates.

- The runoff from any low-sulphur metavolcanics used in construction or as cover will be neutral and will contain low metal concentrations.

- Long-term testing has demonstrated that the discharge from metavolcanics with an elevated sulphur content (i.e., greater than 0.8 wt%) can be acidic and contain high metal concentrations.

- Significant excess neutralization capacity is present in the proposed waste rock and PK materials to be placed in the North Pile. This is true even for a mixture consisting of high-sulphur metavolcanic rock and low-carbonate kimberlite. Long-term testing indicates that the discharge from such a mixture is neutral with low metal concentrations.

- Leach testing of alkaline materials (cemented paste backfill, cement, grout, and concrete) indicates that resulting discharges are alkaline and can contain a limited number of metals at elevated concentrations, most notably aluminum, copper, and lead.

- A comparison between groundwater quality data and average long-term kinetic testing results of host rock units show good agreement.

Geochemical monitoring has been ongoing at the Mine during operations, and includes characterization of rock encountered on site during construction and mining as well as on-going water quality monitoring at areas on site where ARD and metal leaching potential has been identified. Results have been reported annually within the ARD and Geochemistry Monitoring Report, as per the Acid/Alkaline Rock Drainage and Geochemical Characterization Plan. Annual reports take into consideration recommendations as provided originally in guidance documents such as Price (1997) or INAC/DIAND (1992) and subsequent changes in guidelines or understanding as documented in more recent guidance documents, such as Mine Environment Neutral Drainage (MEND, 2009) and International Network for Acid Prevention (INAP, 2010). Monitoring program results for geochemical characterization of metavolcanics, granite and kimberlite mine
rock samples in recent years have been consistent with the ARD testing results and trends in the EAR and subsequent geochemical monitoring.

Waste rock classification and handling on site is currently based on lithological designation and sulphur content. Rock containing greater than 0.17% sulphur is handled as if it were PAG. This criterion was imposed as the data available at the time of the EAR preparation and hearings was insufficient to support a sulphur cut-off criterion greater than 0.17 wt% (De Beers, 2002). The results of the ongoing geochemical evaluation (i.e., kinetic testing) conducted after the EAR indicated that granite or metavolcanic rock containing up to 0.29% sulphur is not likely to generate acidity; however, it is generally difficult to distinguish the amount of sulphide in the metavolcanic rock without analytical testing. Therefore, the practice during operations was to handle all metavolcanic rock as if it were PAG, regardless of sulphur content (Golder, 2014b).

3.3.2.1 North Pile Runoff Quality

Water quality monitoring at the North Pile temporary sumps began in 2005, and after these were incorporated into the East Cell in 2011, monitoring was continued at the perimeter sumps located around the permanent embankment of the North Pile. The objective of monitoring each individual sump and ditch is to evaluate the composition of runoff from different areas in the North Pile over time.

Water quality samples were collected from PS1, PS2, PS3, PS4, PS5, and TS4 in 2017. The results of sump water quality monitoring are presented in the 2017 ARD Geochemistry Report (Arktis, 2018b). The range of concentrations observed in North Pile sump water samples in 2017 are included as presented in Table 3.5.

Table 3.5 2017 North Pile Sump Water Quality

<table>
<thead>
<tr>
<th>Parameter (units)</th>
<th>Range</th>
<th>Average of All Data&lt;sup&gt;(a)&lt;/sup&gt;</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.12 - 8.99</td>
<td>7.76</td>
<td>60</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td>&lt;3 - 170</td>
<td>9.23</td>
<td>59</td>
</tr>
<tr>
<td>Total Dissolved Solids (mg/L)</td>
<td>78.4 - 3750</td>
<td>1133</td>
<td>60</td>
</tr>
<tr>
<td><strong>Inorganics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Ammonia, as N (mg/L)</td>
<td>&lt;0.005 - 8.67</td>
<td>0.717</td>
<td>59</td>
</tr>
<tr>
<td>Nitrate, as N (mg/L)</td>
<td>1.73 - 267</td>
<td>59.9</td>
<td>55</td>
</tr>
<tr>
<td>Nitrite, as N (mg/L)</td>
<td>0.001 - 1.20</td>
<td>0.145</td>
<td>55</td>
</tr>
<tr>
<td>Total Phosphorus (mg/L)</td>
<td>0.002 - 0.275</td>
<td>0.032</td>
<td>59</td>
</tr>
<tr>
<td>Fluoride (mg/L)</td>
<td>0.157 - 0.680</td>
<td>0.406</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total Metals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Aluminum (µg/L)</td>
<td>&lt;3.0 - 2190</td>
<td>134</td>
<td>53</td>
</tr>
<tr>
<td>Total Arsenic (µg/L)</td>
<td>0.075 - 2.50</td>
<td>0.317</td>
<td>55</td>
</tr>
<tr>
<td>Total Chromium (µg/L)</td>
<td>0.077 - 28.9</td>
<td>1.65</td>
<td>54</td>
</tr>
</tbody>
</table>
### Parameter (units)

<table>
<thead>
<tr>
<th>Total Copper (µg/L)</th>
<th>0.680 - 5.72</th>
<th>2.58</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Lead (µg/L)</td>
<td>0.018 - 1.81</td>
<td>0.195</td>
<td>53</td>
</tr>
<tr>
<td>Total Nickel (µg/L)</td>
<td>6.82 - 166</td>
<td>41.2</td>
<td>56</td>
</tr>
<tr>
<td>Total Zinc (µg/L)</td>
<td>0.890 - 55</td>
<td>7.54</td>
<td>56</td>
</tr>
</tbody>
</table>

#### Dissolved Metals

| Dissolved Aluminum (µg/L) | 1.23 - 39.1 | 13.2   | 53 |
| Dissolved Arsenic (µg/L)  | 0.064 - 2.35 | 0.28   | 55 |
| Dissolved Chromium (µg/L) | 0.060 - 4.17 | 0.439  | 54 |
| Dissolved Copper (µg/L)   | 0.610 - 5.53 | 2.3    | 54 |
| Dissolved Lead (µg/L)     | <0.01 - 0.250 | 0.027  | 53 |
| Dissolved Nickel (µg/L)   | 5.42 - 161   | 37.4   | 56 |
| Dissolved Zinc (µg/L)     | <1 - 33.1    | 6.82   | 52 |

Source: Arktis (2018b)

**Notes:**

a Sumps include PS1, PS2, PS3, PS4, PS5, and TS4.
b Non-detected values considered to be at detection limit for calculations.

North Pile sump water has a calcium-magnesium-sulphate to a calcium-magnesium-chloride type composition. The slightly alkaline pH and low metals concentrations supports the conclusions of the ARD and metal leaching assessment.

Minor differences existed in water quality trends in the sumps and water discharged from SNP 02-02. Sump PS3, PS4 and PS5 was higher in sulphate and nitrate, PS3 and PS5 was higher in nitrite, and PS4 and TS4 were relatively elevated in ammonia. PS3, PS4 and TS4 was higher in fluoride. PS1 to PS4 were elevated in copper, while nickel and strontium was elevated in PS3 and PS4, and cobalt was elevated in PS3 and PS5 (Arktis, 2018b).

### 3.3.3 Groundwater Quality

Groundwater chemistry was initially characterized during the 2001 Hydrogeological and Geochemistry program in support of the EAR (De Beers, 2002). Groundwater analytical results from this program indicated weak to moderate mineralization with total dissolved solids (TDS) ranging from 5 mg/L to 1,630 mg/L. The mineralization was weakest in the upper metavolcanics units and increased with depth in the metavolcanics and with transition to granitic material. The data indicated that calcium and chloride are the dominant mineral species contributing to TDS in the granite groundwater, whereas bicarbonate, calcium and magnesium are the predominant species in the kimberlite and metavolcanics. Tabulated baseline groundwater quality results are presented within the EAR (De Beers, 2002). The predominance of calcium and chloride in the granite groundwater is consistent with deep groundwater in Canadian Shield host rock formations. Except for cadmium, cobalt, mercury and zinc, which were present at very low concentrations or non-detect, trace metal concentrations in the groundwater samples were generally 10 to 20 times those...
measured in Snap Lake water (Section 3.3.4). In a limited number of the samples, iron, manganese, chloride and TDS exceeded drinking water guidelines (CCME, 1999 with 2000 updates) of 300 µg/L, 50 µg/L, 250 µg/L and 500 mg/L, respectively.

During the operations phase, and prior to mine flooding, water that entered into the underground mine workings was collected in the main mine sump (SNP 02-01) and then pumped to the WTP. Mine dewatering rates (as seepage) are discussed in Section 3.2.6. Monitoring of pumped water volumes from the underground mine workings began in June 2004 at the sump, SNP 02-01, and continued until January, 2017 during flooding of the mine.

The main factor that influences the composition of mine water is groundwater inflow (Arktis, 2017b). Inflow of lake water; interaction of mined rock and mine openings with water; and activities associated with mining such as explosive and cement or grout use also influence the composition of mine water.

To characterize groundwater quality through the life of mine leading up to the permanent flooding of the underground in early 2017, selected results of water quality monitoring at SNP 02-01 through December 31, 2016 are presented in Figure 3.18 (Arktis, 2017b). Predicted concentrations in the mine water as presented in the EAR (De Beers, 2002) and the 2013 Base Case Site Water Quality Model (De Beers, 2013b) are also provided in Figure 3.18 for comparison purposes, for parameters where available. Additional mine water quality data is provided in the Snap Lake Mine Acid/Alkaline Rock Drainage and Geochemical Characterization 2016 Annual Report (Arktis, 2017b).

As described in Section 3.2.6, the 2015 underground seepage model (Itasca, 2015) concluded that the main source of seepage to the mine is Snap Lake; however footwall seepage contributes relatively elevated TDS. Historically measured TDS concentrations in footwall seepage ranged from <200 mg/L to 19,100 mg/L (sample FW 05, November 5, 2013) with a mean of 6,122 mg/L, whereas hanging wall seepage was generally less than 500 mg/L TDS, with a mean of 247 mg/L (Itasca, 2016).

In 2016, prior to underground flooding, mine water inflow rates remained stable and TDS loading rates increased throughout 2016 as expected: TDS concentrations ranged from 723 to 892 mg/L (Arktis, 2017b).

3.3.4 Surface Water Quality

A baseline study of water quality conditions was undertaken between 1998 and 2001 to support development of the EAR (De Beers, 2002). Surface water was collected from Snap Lake, streams flowing into and out of Snap Lake and from small lakes in the Snap Lake watershed (Figure 3.19).

Snap Lake is a relatively clear, soft water lake, with a neutral to slightly acidic pH. Baseline samples collected from stations in Snap Lake in 1999 and 2001 had pH values that were occasionally lower than the minimum CCME Canadian Water Quality Guideline (CWQG) of 6.5. The alkalinity of water can be used to gauge the sensitivity of lakes to acid deposition. Because of its low alkalinity (median = 6 mg/L), Snap Lake is susceptible to acidification, as are many lakes in the Canadian Shield. Median TDS concentrations were very low, typically near laboratory detection limits. Most metals in Snap Lake were present in low concentrations, with medians below CWQG; individual samples were occasionally above CWQG for cadmium, copper, iron, lead, silver and zinc.
Figure 3.18  Time-Series Graphs for Selected Mine Water Parameters

Source: Arktis (2017b)

Notes: mg/L = milligrams per litre; Ca = calcium; Cl = chloride; Mg = magnesium; K = potassium; Na = sodium; Fe = iron; TDS = total dissolved solids; Al = aluminium; As = arsenic; Cd = cadmium; F = fluorine; Cr = chromium; Cu = copper; Ni = nickel; Pb = lead; Zn = zinc; Ba = barium; Cs = cesium; Li = lithium; Mn = manganese; Tl = thallium; B = boron; Co = cobalt; Mo = molybdenum; U = uranium; Sr = strontium; CO$_3$ = carbonate; HCO$_3$ = bicarbonate; SO$_4$ = sulphate.
Figure 3.18  Time-Series Graphs for Selected Mine Water Parameters (continued)

Source: Arktis (2017b)

Notes: mg/L = milligrams per litre; Ca = calcium; Cl = chloride; Mg = magnesium; K = potassium; Na = sodium; Fe = iron; TDS = total dissolved solids; Al = aluminium; As = arsenic; Cd = cadmium; F = fluorine; Cr = chromium; Cu = copper; Ni = nickel; Pb = lead; Zn = zinc; Ba = barium; Cs = cesium; Li = lithium; Mn = manganese; Tl = thallium; B = boron; Co = cobalt; Mo = molybdenum; U = uranium; Sr = strontium; CO₃ = carbonate; HCO₃ = bicarbonate; SO₄ = sulphate.
Some area lakes will stratify into two non-mixing layers in the summer: a layer of warmer, less dense water lying on a cooler, dense layer, with a thin transitional layer between. The reverse can happen in the winter, with very cold (<4°C), less-dense water overlying warmer, denser water (approximately 4°C). Snap Lake does not become stratified in summer or winter. It is relatively well mixed in the summer with limited vertical gradients of temperature, dissolved oxygen or pH.
Snap Lake has a relatively shallow mean depth of 5.2 m and two particularly deep areas, one at the extreme west end of the lake (45 m) and the other at the southeast tip of the northwest peninsula (24 m). Wind-driven circulation of bottom and surface waters results in a well-mixed system throughout most of the lake. The northwest arm of Snap Lake is connected to the main basin of Snap Lake year-round, although the circulation into the northwest arm is reduced relative to circulation in the main basin (De Beers, 2014a). During the winter, the temperature profile increases and dissolved oxygen levels decrease with depth. The decline in oxygen is likely due to consumption resulting from bacterial decomposition of lake-bottom organic matter. Dissolved oxygen concentrations remain above CWQG minimum values at the surface, indicating adequate oxygen levels for aquatic life. In March 1999, dissolved oxygen concentrations were slightly below minimum CWQG aquatic life levels at the deepest sampling location. Low dissolved oxygen (DO) concentrations are common in lakes in winter owing to oxygen consumption and lack of mixing.

The project EAR (De Beers, 2002) anticipated that concentrations of water quality parameters associated with the treated effluent discharge would reach background concentrations within 44 km downstream of Snap Lake. As predicted, water quality has changed in Snap Lake and downstream since treated effluent discharge from the Mine began. Concentrations of total dissolved solids (TDS), nutrients, and some metals increased from baseline concentrations in Snap Lake due to the discharge of treated effluent.

During the transition from active mining to ECM, a water quality and hydrology study was completed to provide a basis for defining the natural variability and update the water quality model downstream of Snap Lake (Golder, 2017a). Water samples were collected during open water and ice-cover periods from May 2015 to April 2017 along the flow path, and from off the flow path for comparison, from the Mine effluent outfall (see Figure 3.20).

Maximum calculated TDS, and major ions concentrations were higher at locations on the flow path compared to locations off the flow path. Metals concentrations were typically similar on and off the flow path, with the exception of six metals (i.e., barium, boron, lithium, molybdenum, strontium and uranium) that are characteristic of the treated effluent, for which the maximum concentrations were higher on the flow path. Concentrations of most parameters were higher on the flow path during ice-covered conditions relative to open-water conditions. Concentrations of TDS ranged from 9.2 to 348 mg/L during ice-covered conditions, and 7.4 to 246 mg/L during open-water conditions on the flow path.

The TDS concentrations ranged from 7.7 to 15.8 mg/L during ice-covered conditions and 7.1 to 12.0 mg/L during open-water conditions off the flow path. Overall, concentrations of TDS, major ions and metals were below AEMP benchmarks.

Concentrations of TDS in both ice-covered and open water conditions decreased with distance from the Mine to MacKay Lake, as shown in Figure 3.21. Based on TDS concentrations as an effluent indicator parameter, effluent was detected at the sampling location at the inlet to MacKay Lake, but not at the Node 22 sampling location for AEMP compliance (Figure 3.21) (Golder, 2017a).
Figure 3.20 Monitoring Locations in the Downstream Watercourses

Source: Golder (2017a)
Due to the significant reduction in effluent discharge during the current ECM period compared to active mining and C&M activities, water quality in Snap Lake is observed to be improving (Figure 3.22). In 2017, concentrations of most water quality parameters related to the Mine’s treated effluent decreased in Snap Lake relative to 2016. In 2017, water quality concentrations in and downstream of Snap Lake were within AEMP benchmarks or historical ranges (Golder, 2018b). Concentrations of Mine-related parameters are expected to continue to decrease in Snap Lake due to reduced discharges to Snap Lake during the Extended Care and Maintenance (ECM) and closure periods.

3.3.5 Sediment Chemistry

A baseline study of sediment quality conditions was undertaken between 1998 and 2001 as part of the project EAR (De Beers, 2002). Fine lake-bottom sediments were collected from four sites in Snap Lake and from a reference lake (see Figure 3.19). Sediments were analyzed for metals, total organic carbon (TOC) and particle size. Sediment quality in both lakes was very similar and consisted predominantly of sand and silt with very little clay. Sediment metal concentrations were also very similar in Snap Lake and the reference lake. Concentrations of several metals (cadmium, chromium, copper and zinc) were above the CCME Canadian Interim Sediment Quality Guidelines (CISQG) (CCME, 1999).
Figure 3.22  TDS in Snap Lake and the Reference Lakes, 2004 to 2017

Source: Golder (2018a)

Notes:
Details on the calculation of the normal range are discussed in Appendix 3D of the 2017 AEMP Annual Report (De Beers 2018a). Data shown are from representative stations within Snap Lake: Diffuser Area = SNAP13 (2004 to April 2006) and SNP 02-20e (July 2006 to 2017); main basin = SNAP05, SNAP08 (2004 to 2017), SNAP11 (2004 to April 2006) and SNAP11A (July 2006 to 2017); northwest arm = SNAP02 (2004 to April 2006), SNAP02A (July 2006 to 2016) and SNAP23 (2007 to 2017); reference lakes = NEL01 to NEL05 and LK13-01 to LK13-05.

SNP = Surveillance Network Program; NEL = Northeast Lake, LK13 = Lake 13; mg/L = milligrams per litre.
Baseline sediment quality in lakes throughout the Lockhart River watershed downstream of the Mine site was generally similar to Snap Lake and the reference lake (De Beers, 2002). Typically, sediment was predominantly sand and silt with very little clay. Concentrations of several metals (cadmium, chromium, copper, lead and zinc) were above CISQG levels in some waterbodies. Copper concentrations were above the CISQG level in more than half of the waterbodies sampled. Concentrations of lead in some waterbodies were also above the less stringent probable effects level (PEL) for aquatic life (CCME, 1999).

Sediment quality monitoring in Snap Lake, Northeast Lake and the reference lakes is completed within the scope of the Aquatic Effects Monitoring Program (AEMP), results of which are reported annually to the MVLWB in the Aquatic Effects Monitoring Program Annual Report. The following paragraphs summarize the sediment quality trends observed through the active mining phase into the current ECM phase; time-series graphs for selected parameters are provided in Figure 3.23. Additional data tables and graphs are provided in the 2018 Aquatic Effects Re-evaluation Report (Golder, 2018a).

Sediment quality results from Snap Lake and the reference lakes noted a large number of significant differences between lakes, interpreted as an indication of high background variation in sediment quality in the region, and not necessarily indicative of an effect of the Mine on sediment quality (Golder, 2018a). Of the metals with significant differences between Snap Lake and reference lakes, calcium, sodium, and strontium displayed statistically significant increasing trends with concentrations above normal ranges in the main basin of Snap Lake during Mine operations, which suggest the concentrations of these metals were influenced by the treated Mine effluent discharge.

Temporal trends in monitoring data through the mining phase indicate that concentrations of several parameters at the diffuser station and in the Snap Lake main basin had increased, likely due to the Mine, an outcome predicted during the EA. From 2004 through 2017, parameters that showed statistically significant increasing trends at the diffuser station and in the main basin of Snap Lake were: available sulphate and potassium, boron, calcium, selenium, silver, sodium and strontium (Golder, 2018a). Of these parameters, available potassium, boron, calcium, silver, sodium and strontium reached concentrations above the normal range at the diffuser station, main basin, or both during recent years (a normal range comparison is not possible for selenium). Average concentrations of some metals, such as chromium and copper, were observed to be higher in Northeast Lake and/or Lake 13 (reference lakes) than in Snap Lake, indicating that concentrations are naturally elevated in this geographic region (Golder, 2016b). Some measured parameters in the sediment samples had lower concentrations than in previous years, some had higher. Such variability is not unexpected given that the sediments are diverse in character and content (Golder, 2017a).

In addition to the parameters with increasing temporal trends at both the diffuser station and in the main basin, statistically significant increasing trends at the diffuser station only (and in the northwest arm for mercury) were noted for total phosphorus and mercury, suggesting a localized effect of the treated effluent at the diffuser station, with mercury concentrations above the normal range since 2009 (Golder, 2018a). As demonstrated in the time series plots (Figure 3.23), the increasing trends interpreted as influenced by the Mine discharge have reversed at the diffuser station or main basin after 2015 or 2016 (Golder, 2018a). This is consistent with the large reduction in treated effluent discharge since the Mine progressed into ECM.
Figure 3.23  Time Series Plots of Key Parameter Mean Concentrations in Sediments, 2004 to 2017
Figure 3.23  Time Series Plots of Key Parameter Mean Concentrations in Sediments, 2004 to 2017 (completed)

Source: Golder (2018a)

Note: The normal range applicable to the diffuser station (i.e., for single samples in Snap Lake) is shown. Benchmark is the CCME Canadian Interim Sediment Quality Guideline for the protection of freshwater aquatic life (CCME, 1999 as revised).
3.4 Biological Environment

3.4.1 Aquatic Habitat and Biota

3.4.1.1 Aquatic Habitat

Aquatic habitat surveys were completed for Snap Lake, streams within the Snap Lake watershed and other local lakes in support of the EAR (De Beers, 2002). The shoreline substrate of Snap Lake is generally a mixture of boulder, exposed bedrock and intermittent cobble; sedge wetlands and marsh areas found in bays and sheltered areas comprise less than 3% of the shoreline. Most near-shore areas have steep gradients leading to deeper water. Shoreline substrates transition at 3 m to 4 m depth to deep water substrates, which consist of a thick layer of loose organic matter. The lake has numerous islands, rocky outcrops and shoals.

Three key habitat types were characterized for Snap Lake: nearshore habitat (shoreline to the 4 m depth contour), open water (>4 m in depth), and shoals. Boulder cobble substrate is the most common shoreline aquatic habitat. The preferred spawning habitat for lake trout is boulder bedrock shoals near deep water, at depths of 2 m to 6 m, fully exposed to wind and wave action. The primary trout spawning habitat is near the centre of Snap Lake; secondary spawning areas exist throughout the lake, however none were located in the immediate vicinity of the Mine.

Pre-development, four streams with limited or unsuitable fish habitat were identified in the Mine footprint that discharge into Snap Lake:

- The flow regime of a shallow, ephemeral drainage was altered with the construction of the PKC (now WMP) during the AEP. This stream was characterized as not suitable for fish habitat;
- The airstrip footprint crosses a shallow, ephemeral stream that drains south into a pond. A culvert was installed under the airstrip to facilitate flow;
- An ephemeral drainage with no defined channel through vegetated terrain drains a small pond located between the Emulsion Plant and AN Storage areas; and
- An ephemeral drainage with no defined channel through vegetated terrain drained a low-lying area in the footprint of the North Pile.

3.4.1.2 Aquatic Biota

Baseline sampling for aquatic organisms in Snap Lake was conducted in 1999 (De Beers, 2002). Phytoplankton, chlorophyll a and nutrient concentrations in Snap Lake were found to be moderately low. This is typical of an oligo-mesotrophic lake characterized by low to moderate productivity with total phosphorus concentrations of 0.005 to 0.010 mg/L. The results for Snap Lake are consistent with those similar lakes in the Slave Geological Province. A discussion of Snap Lake water quality is presented Section 3.3.4.

The zooplankton community structure varied monthly, with average maximum biomass recorded in July. Also, zooplankton ash-free dry weight ranged from 0.5 to 27.5 g/m². Overall, the ash-free dry weight increased over the open water season and reached a maximum in September at all three sampling sites in Snap Lake.
Changes were observed in the plankton community of Snap Lake; however, these changes have not adversely affected the function of this community as a key part of the food chain for fish (Golder, 2018b). Increases in zooplankton and chlorophyll-a and -c concentrations in Snap Lake and reference lakes between 2016 and 2017, indicated a regional rather than Mine-related effect. Increases in phytoplankton suggest the operation of the Mine has enhanced the growth of small plants in Snap Lake, probably related to additional nutrients, and that Mine effluent has not been toxic to the small plants. Increases in water fleas, which are considered sensitive to total dissolved solids (salts) in the treated effluent, were still within the normal range of natural variability in the main basin of Snap Lake and no major changes had occurred to other zooplankton compared to previous years, suggesting that Mine effluent is not toxic to the small animals in Snap Lake.

Benthic invertebrates were collected at four sites in Snap Lake during the fall sampling program in 1999 (Figure 3.19). Mean total benthic invertebrate abundance in the lake varied between 5,000 and 7,400 organisms/m². Total taxonomic richness (the number of taxa at the lowest level of identification) varied little among sites. The total number of taxa found (calculated by pooling all the replicate samples at a site) was between 27 and 30. The invertebrate community in Snap Lake was dominated by dipterans and nematodes. Mine-related changes were detected in 2015 in the benthic invertebrate community in the main basin of Snap Lake relative to previous years (Golder, 2017b). The total number of invertebrates and the number of the most common groups of invertebrates exceeded ranges that are considered normal for Snap Lake, meaning that these invertebrates were more abundant than the natural range in this lake.

In 1999, seven species of fish were captured in Snap Lake, including longnose sucker (Catostomus catostomus), burbot (Lota lota), lake trout (Salvelinus namaycush), round whitefish (Prosopium cylindraceum), Arctic grayling (Thymallus arcticus), lake chub (Couesius plumbeus) and slimy sculpin (Cottus cognatus). Five species were captured during gill net sampling in 2016: Arctic grayling, lake chub, lake trout, longnose sucker, and round whitefish (Golder, 2017b). The results from the 2016 program indicated that the fish community composition in Snap Lake was similar to previous years. A fish community monitoring program was also completed in 2016 and that study concluded there were no indications that fish in Snap Lake were being affected by the Mine and that differences between Snap Lake and the reference lakes could be reasonably attributed to natural variability. Based on the 2016 results, fish were healthy and abundant in Snap Lake (Golder, 2017b).

Monitoring activities of the freshwater biota and habitat at Snap Lake and additional selected reference lakes are completed by De Beers within the requirements of the Aquatics Effects Monitoring Program (AEMP) and reported annually to the MVLWB in the Aquatics Effects Monitoring Program Annual Report. Monitoring focuses on a variety of parameters including: water quality, plankton, sediment quality, benthic invertebrates, and fish health (including tissue chemistry and community). All monitoring components, except for benthic invertebrates and fish health, are currently undertaken annually. Benthic invertebrates and fish health monitoring occurs on a three-year cycle. The studies began in 2004 and were included as a component of the 2015 and 2016 AEMPs. An annual fish tasting event, an important environmental and community monitoring tool to obtain feedback from community members relating to the taste, texture, general condition and health of lake trout and round whitefish in Snap Lake, is included within the AEMP reporting, and several targeted special studies (e.g., Downstream Lakes Special Study, Littoral Zone Special Study, Nutrient Special Study, etc.) have also been completed to support the continued improvement of the existing AEMP.
3.4.2 Vegetation and Wildlife Habitat

The RSA for vegetation and wildlife is situated within the Taiga Shield Ecozone in the High Sub-Arctic Ecoclimatic Region (Figure 3.24). Throughout the taiga, cool air temperatures, a short growing season, geology and recent glaciation have resulted in lower biological productivity and diversity than in the more southerly parts of Canada. The few plant species that thrive have adapted to the harsh climate and poor soils. Because of the cold conditions, vegetation does not decompose rapidly into soil but rather is preserved in the form of peat, which covers most low-lying areas.

The taiga forms the transition between forested lands to the south and open tundra (barren lands) to the north. The predominant vegetation of the taiga consists of open, very stunted stands of black spruce and tamarack with secondary white spruce and a ground cover of dwarf birch, willow, ericaceous shrubs, cotton grass, lichen and moss. Poorly drained sites usually support tussocks of sedge, cotton grass and sphagnum moss. Low shrub tundra, consisting of dwarf birch and willow, are also common. The peak flowering periods for most plants in this ecozone occurs between July 1 and July 31. In support of the EAR (De Beers, 2002), the RSA was characterized per the Ecological Land Classification (ELC) as predominantly heath/boulder, which occupies 46% of the RSA. The water ELC unit, which includes lakes, rivers, and streams, comprised 36% of the RSA, and the remaining ELC units comprised 19% of the RSA.

The terrestrial environment local study area (LSA) is defined as the mine footprint with a 500 m buffer, occupying an area of 1,435 ha (Figure 3.25). Similar to the RSA, the majority of the LSA in a pre-development condition was dominated by heath/boulder (55%), while heath tundra accounted for only 0.1% of the LSA. Water comprises 31% of the LSA.

Vegetation monitoring at the Mine is completed as per the Vegetation Monitoring Program, which includes annual/interval monitoring that focuses on Area of Impact, ELC area, and passive regeneration monitoring programs (De Beers, 2008b). Results are reported annually within the VMP Annual Report. Dustfall monitoring is also completed as per the VMP and Air Quality and Emissions Monitoring and Management Plan in order to assess potential effects to vegetation communities. Dustfall results are reported annually within the VMP Annual Report, and are discussed further in Section 3.1.2.2.

Area of Impact and ELC monitoring are completed using QuickBird satellite images, which are captured every 5 years. The 2013 vegetation monitoring program identified 194.9 ha of the local study area (LSA) and esker complex (located in the RSA) was disturbed. Specific to the LSA (Figure 3.25), the disturbed area was 192.4 ha, which represented 13.4% of the total LSA. As of 2018, the total land disturbance associated with the Project within the LSA is 188 ha based on revised estimates from the current site plan (De Beers, 2018c). The current land disturbance area is less than the predicted disturbance area (13%) in the LSA.

3.4.3 Terrestrial and Avian Wildlife

For the development of the EAR (De Beers, 2002), the potential impacts of mining activities were focused on a group of valued ecosystem components (VECs) that were selected based on the ecological, social, cultural and economic aspects of the ecosystem. A detailed description of the selection processes is provided within the project EAR (De Beers, 2002).
Figure 3.24  Terrestrial Environment Regional Study Area
Figure 3.25  Terrestrial Environment Local Study Area
The eight wildlife VECs that were selected for study in the project EAR include:

- Bathurst caribou herds;
- Barren-ground grizzly bears;
- Wolves;
- Foxes;
- Wolverines;
- Upland breeding birds (passerines, shorebirds, ptarmigan);
- Raptors (peregrine falcon, gyrfalcon); and
- Waterfowl.

Baseline and effects monitoring data concerning each of the above wildlife VECs is presented in the following sections. Terrestrial wildlife and habitat data collection has been ongoing since the EA stage, and De Beers began completion of wildlife effects monitoring at the wildlife study area (31 km radius of the project site) in 2005. At present, wildlife and habitat data is collected as per the Wildlife Effects Management Plan (WEMP). Results are reported annually in the Wildlife Effects Monitoring Program Annual Report and the Wildlife and Wildlife Habitat Protection Annual Report.

Due to the large degree of natural variation inherent in ecosystems, it is often difficult to detect indirect effects with only a few years of data. Therefore, a more comprehensive analysis and discussion of all data from the WEMP and WWHPP has been completed every five years. In 2013, monitoring data collected from 1999 to December 2012 was compiled and analyzed to assess environmental effects on wildlife (Golder, 2013). The effects of the Snap Lake Mine to wildlife have been within the range predicted in the EAR (De Beers, 2002). Further data collection and ongoing analyses will help to assess if any identified changes to wildlife are related to the Mine, or natural factors.

### 3.4.3.1 Bathurst Caribou Herd

The Bathurst caribou herd spends the winter south of the treeline, usually concentrated in areas to the southeast and northwest of the eastern arm of Great Slave Lake. The herd gathers in spring in preparation for a very quick and direct northern migration to the calving grounds west of Bathurst Inlet. After calving is completed, caribou begin a much less direct migration south to the wintering grounds.

Within the last 30 years, the Bathurst herd caribou population has rapidly declined (GWNT, 2018a). Results of photographic calving ground surveys show that the Bathurst herd declined from an historic peak of over 450,000 in 1986 to an estimated ~35,000 caribou in 2009 (Nishi et al., 2014). Following management intervention (WRRB, 2016), primarily in the form of harvest restrictions, the trend appeared to stabilize between 2009 and 2012. However, the population further declined approximately 40% from 2012 to 2015 and is now estimated at approximately 20,000 caribou (Boulanger et al., 2016). The annual and seasonal ranges of the Bathurst herd, and their intensity of use by caribou, based on the analysis of available satellite collar information between 1996 and 2014 (19 years of data), is shown in Figure 3.26 (GWNT, 2018a). The Bathurst caribou population is currently estimated to be approximately 20,000 animals (19,769 ± 7,420) (Boulanger et al., 2016), representing a decline of over 96% from a mid-1980s population estimate of approximately 450,000.
Figure 3.26  Annual and Seasonal Ranges of the Bathurst Caribou Herd Based on Satellite Telemetry Data from 1996 to 2014

Source: GNWT (2018a)

Note: Darker colours indicate higher use by caribou.
Aerial surveys for caribou were conducted in the RSA between 1999 and 2002 to support development of the project EAR (De Beers, 2002). From 1999 to 2002, 668 caribou groups were observed in the study area during aerial surveys. Most of these groups (92%) were made up of 50 or less caribou. The number of caribou observed during each of the migration periods varied greatly. For example, less than 1,500 caribou were estimated to be within the study area during the northern migration period in both 1999 and 2001. In contrast, there were approximately 15,000 animals in the study area during the northern migrations of 2000 and 2002, and about 27,000 caribou in the study area during the post-calving migration in 1999. It is likely that some of the observed changes were influenced by the decline in the Bathurst caribou herd, and the bears, wolverine, and wolves that depend on caribou (Golder, 2013).

The combined aerial survey information on caribou group size and location suggests that caribou generally moved through the northern and western half of the study area during northern migrations. Few caribou were observed in the eastern part of the study area during the northern migration. A large number of caribou observations were recorded between Camsell Lake and MacKay Lake. Although the distribution of caribou was more uniform during the southern migrations, again, the western portion of the study area appeared to contain more caribou.

Caribou behavior during the northern migrations has been similar among years while behavior during the post-calving migrations (June 30 to December 31) has varied from year to year. For both migration periods, however, behavior has varied among habitats. During the northern migrations, caribou groups on frozen lakes were more likely to be moving than groups in heath tundra habitat. During the post-calving migrations, caribou were more likely to be feeding and resting in spruce forest and sedge wetland habitats than they were in all other habitat types. The number of nursery (with calves) and non-nursery (without calves) groups was different from year to year. In 2002, 20% of the caribou groups observed contained calves, while in 2001, approximately 3% of caribou groups contained calves.

Since the completion of baseline studies for the EAR (De Beers, 2002) caribou have been monitored through the movements of satellite-collared caribou, observations by employees at the Mine site, and with aerial surveys by helicopter. Aerial surveys during the spring northern migration are no longer a component of the Wildlife Effects Monitoring Program (WEMP).

They were determined to be ineffective for assessing mine-related effects by wildlife managers and monitoring agencies and were discontinued in 2010. The number of caribou observed has continued to vary significantly from year to year since monitoring began in 1999 and likely reflects the reduced herd size of Bathurst caribou (GNWT, 2016). In 2012, one caribou was observed during two post-calving migration aerial surveys. In 2014, 226 caribou were observed during an aerial reconnaissance survey. Reconnaissance surveys are completed to assess if sufficient caribou groups were present in the RSA to complete behavioural scan surveys. No post-calving migration aerial surveys were completed in 2013, 2014, 2015, 2016, or 2017 because the location of collared caribou cows remained outside of the RSA and the requirement for monitoring was not triggered. De Beers contributes to monitoring programs completed by the Department of Environment and Natural Resources (ENR), Government of the Northwest Territories (GNWT) that were part of the GNWT’s Barren-ground Caribou Management Strategy (GNWT, 2011) in lieu of completing aerial surveys. De Beers’ support of the Barren-ground Caribou Management Strategy was reviewed and agreed to by the SLEMA.
3.4.3.2 Wolf

Traditional Knowledge indicates that eskers provide important travel routes for many mammal species such as caribou, muskox and fur-bearers, and den sites for carnivores, especially wolves. The locations of all active wolf and fox dens along eskers were recorded during esker surveys in 1999 and 2000. The number of active wolf dens in the study area ranged from two to five from 1999 through 2002.

Wolves were included as VECs in the WEMP between 1999 and 2010 but were discontinued as agreed by government biologists, community organizations, mine monitoring agencies, and the mines at a workshop in 2010 (Handley J., 2010).

3.4.3.3 Grizzly Bear

No active grizzly bear dens have been located within the study area. However, grizzly bear signs were observed in seasonally preferred habitat in the study area in 2001 and 2002. An average of 48% of plots in sedge wetland habitat and 45% in riparian habitat contained fresh grizzly bear signs in 2001 and 2002. Although not a VEC, black bears were observed incidentally on several occasions.

Due to limited and variable results, the bear monitoring study design was revised in 2010 to include the use of 40 hair snagging stations that are inspected for the presence of grizzly and black bear hair. Results since this time have indicated that grizzly bears continue to be present in the study area, although in low levels (Golder, 2013). In 2012, the hair snagging program was discontinued in favour of participating in a regional grizzly bear program in 2013 and 2014 that would help GNWT monitor and assess cumulative effects (ERM Rescan, 2012). The regional program included hair snagging stations distributed across a 30,000 km² area (north and south study areas combined) surrounding the Ekati, Diavik, Gahcho Kué and Snap Lake Mines. A total of 1,108 samples of hair were collected over the course of the sampling period: 263 from the Snap Lake Mine and 845 from Gahcho Kué Mine.

3.4.3.4 Wolverine

Baseline snow track surveys indicated the presence of wolverine in the study area and incidental sightings of wolverine were made every year from 1999 through 2002. Estimates of wolverine track density from 1999 through 2002 encompassed the range observed during studies for the Ekati Mine.

From 2003 to 2012, winter track surveys were completed using fifty 4 km-long transects that passed through boulder, heath tundra/boulder, and shoreline areas. In 2012, the snow track survey results indicated that wolverine continued to be present in the RSA. The percent of transects with snow-tracks in 2012 was the lowest level of wolverine activity observed during the 2003 to 2012 monitoring period. Although indices of wolverine presence have been annually variable, there was strong congruence between the patterns observed and the trend in Bathurst caribou numbers. The use of snow-track surveys to monitor wolverines was discontinued at the close of the 2012 program, as De Beers opted to participate in a regional and standardized wolverine hair snagging program that supports management and conservation of wolverines by the GNWT (Golder, 2013). De Beers has undertaken two consecutive years of sampling (2013 and 2014). Results from 2014 identified 15 individual wolverines (8 male and 7 female) in the study area around the Mine.
3.4.3.5 Upland Breeding Birds

A total of 39 species of passerines (small perching birds), shorebirds, gulls, ravens and ptarmigan were observed within the study area from 1999 through 2001. Of these, 23 upland breeding species (passerines, ptarmigan and shorebirds) were identified as breeding within the study area. Average annual density from 1999 through 2001 ranged from 0.3 individuals/0.25 km$^2$ on control sites for lesser yellowlegs to 40.1 individuals/0.25 km$^2$ on mine sites for Lapland longspurs. Although estimates of species richness and diversity were highly variable among years, they were similar on control and Mine plots each year from 1999 through 2001.

Monitoring of upland breeding birds is not included within the scope of the WEMP.

3.4.3.6 Raptors

Eight species of raptors (birds of prey) were observed in the RSA during the 1999 and 2000 baseline surveys, but only two (peregrine falcon and gyrfalcon) were confirmed as breeders. From 1999 to 2010, 12 falcon nest sites were observed in the study area. Productivity ranged from 1.0 to 3.0 chicks per productive nest for gyrfalcons and 1.5 to 2.5 chicks per productive nest for peregrine falcons from 2000 through 2002. Both the density and productivity of falcon nests in the RSA were consistent with other Arctic data.

Results of monitoring data from 1999 to 2010 demonstrated that raptor species continued to use nest sites in the RSA. The results of the occupancy analysis indicated either a pattern of increasing likelihood of occupancy with close proximity to the Mine or that occupancy did not vary spatially or annually.

Monitoring of raptor nests in the RSA was discontinued as a component of the WEMP based on recommendations by regulators, community organizations, and other interested parties at a 2010 mine monitoring workshop (Handley J., 2010). As suggested during this workshop, De Beers planned to continue monitoring raptor nests as an in-kind contribution to support regional databases administered by the GNWT and the North American Peregrine Falcon survey approximately every five years (De Beers, 2017d). In 2015 such a raptor nest survey was conducted in order to provide in kind raptor nest use and productivity data to the National Peregrine Falcon Recovery Program survey. Out of 14 nesting sites surveyed in 2015, three sites were occupied, with fledglings observed at one site.

3.4.3.7 Waterfowl

Eighteen lakes in the study area were surveyed for waterfowl in 1999 and 2000. In each case, the entire lake was surveyed and observations were standardized by length of shoreline. Average densities of 2.2 and 2.4 individuals per 1,000 m of shoreline (N = 18 lakes) were recorded in June of 1999 and 2000, respectively. Low primary productivity in lakes and marginal nesting habitat may be associated with low waterfowl density.

Monitoring of waterfowl is not included within the scope of the WEMP.
4.  PROJECT DESCRIPTION

4.1  Location and Access

The Snap Lake Mine is located approximately 220 km northeast of Yellowknife, NWT, and 80 km northwest of De Beers’ Gahcho Kué Mine, located at latitude and longitude 63° 35'30" North and 110° 52'00" West, respectively (see Figure 2.1). The Mine is situated on a peninsula located on the western shore of Snap Lake. The developed area of the site, including the winter access spur road, is approximately 250 ha and the total land lease area identified for the site is 443 ha (Figure 4.1).

Year-round access to the remote mine site is available by aircraft, using the on-site airstrip. There is no permanent overland access to the Mine. Seasonal ground access to the Mine is provided by a De Beers’ operated 35 km access spur road that extends east from the Tibbitt-Contwoyto Winter Road, both of which were constructed annually during operations and typically open for an 8-10 week period during late January through March. The Tibbitt-Contwoyto Winter Road also services the Gahcho Kué, Ekati and Diavik diamond mines, and use of the winter road is restricted, subject to driver training, safety, weather and other conditions of use.

4.2  Site History

The following paragraphs summarize the history of the initial discovery and evolution of the project, as described in the Consolidated Project Description (De Beers, 2003). De Beers purchased the project in the fall of 2000 and remains the project owner.

In 1997, a diamond-bearing kimberlite dyke was discovered at the site by Winspear Resources. During 1998 and 1999, exploration continued with diamond drilling. In early 1999, bulk samples of kimberlite were extracted from two pits on the northwest peninsula. These samples were trucked to a processing plant at the Lupin Mine. The results provided sufficient confidence in the grade and diamond values to proceed to a pre-feasibility study.

The pre-feasibility study was completed in April 2000, which included a pre-feasibility level plan for the establishment and operation of an underground mine and associated support facilities for an ore resource of approximately 12.6 million tonnes. Continued exploration and a resource study update in August 2000 resulted in an increased resource estimate of approximately 22.8 million tonnes of ore, which included dilution of approximately 20%.

An advanced exploration project (AEP) was permitted and conducted in 1999 to 2001. This AEP was conducted to further delineate the grade and value of the kimberlite beneath Snap Lake through the extraction, sampling and testing of a bulk sample. An optimization study was carried out concurrently to provide more detail on the underground mine and surface facility designs, mine operation plans, construction schedules, and costs. The bulk sampling program included the underground extraction and on-site processing of up to 40,000 tonnes of kimberlite, which was completed in late 2001. Surface infrastructure was constructed to support the AEP, including an on-site processing plant, a Processed Kimberlite Containment (PKC) facility (later repurposed as the water management pond (WMP)), a power generating facility, a camp, an airstrip, an explosives storage facility, a fresh water intake system, and fuel storage and distribution facilities. De Beers was granted a Type ‘B’ Water Licence and a Class ‘A’ Land Use Permit for these activities.
During the AEP, water from the underground workings and processed kimberlite were stored in the PKC facility. However, the function of the PKC facility was revised after the AEP, and was subsequently renamed as the WMP. The revised function and purpose of the WMP for the remainder of the mine operation was to provide water storage that accommodated temporary or seasonal increases in flow, temporary shutdown of the water treatment plant, and to provide control of seepage and runoff from the mine site.
In late 2001, the project went into care and maintenance mode. Pumping equipment was removed, and the underground workings developed during the AEP were allowed to flood. The project remained in care and maintenance until completion of permitting for full mine development in mid-2004.

The Project Environmental Assessment Report (EAR) (De Beers, 2002) was submitted to the Mackenzie Valley Environmental Impact Review Board in February of 2002 and the Mine was approved on October 10, 2003. At this time, the project proceeded to the licensing phase with the Mackenzie Valley Land and Water Board (MVLWB).

The following list provides a timeline for significant project milestones following the completion and approval of the Environmental Assessment (EA):

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
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</thead>
<tbody>
<tr>
<td><strong>Development and Operations Phase</strong></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>De Beers receives the necessary Water Licence, Land Use Permit, Land Leases and Environmental Agreement to begin construction activities at the Project site.</td>
</tr>
<tr>
<td>2005</td>
<td>Construction of the Starter Cell of the North Pile, including relevant water control structures begins (De Beers, 2015a).</td>
</tr>
<tr>
<td>2006</td>
<td>Construction and commissioning of mine and infrastructure facilities continues.</td>
</tr>
<tr>
<td>2007</td>
<td>Deposition of processed kimberlite (PK) and waste rock into the North Pile Starter Cell begins (De Beers, 2015a).</td>
</tr>
<tr>
<td>2009</td>
<td>The site enters into care and maintenance mode due to the global economic downturn. Operational activities resume in the same year, and in 2010 production is ramped up, with associated staffing level increases.</td>
</tr>
<tr>
<td>2011</td>
<td>The Project is issued a renewed Land Use Permit (MV2010D0053) with a 4 year term from the MVLWB. In November of 2011, Anglo American Public Limited Company (PLC) acquires the Oppenheimer family’s 40% interest in De Beers to increase their shareholding to 85%.</td>
</tr>
<tr>
<td>2012</td>
<td>The Project is issued a renewed Type A Water Licence (MV2011L2-0004) with an 8 year term from the MVLWB.</td>
</tr>
<tr>
<td>2013</td>
<td>An application is submitted to amend the Type A Water Licence.</td>
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<tr>
<td>2014</td>
<td>The MVLWB issues an updated Environmental Assessment (EA1314-02) that evaluates potential impacts due to De Beers’ proposal to increase the upper limit for the average total dissolved solids (TDS) concentration in Snap Lake. Based on the results of the updated EA, a second application to amend the Water Licence is submitted for approval.</td>
</tr>
<tr>
<td>2015</td>
<td>The Project is issued an amended Type A Water Licence.</td>
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</tbody>
</table>

**Care and Maintenance Phase**

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
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</thead>
<tbody>
<tr>
<td>2015</td>
<td>On December 4, 2015, the Mine enters into Care and Maintenance (C&amp;M) mode.</td>
</tr>
</tbody>
</table>
### Year | Milestone
--- | ---
2017 | As part of on-going evaluation of the Project, an Extended Care and Maintenance (ECM) plan is submitted to the MVLWB, and the Mine transitions to ECM. The Mine's underground workings are decommissioned and allowed to flood. The Project is issued a renewed Land Use Permit (MV2017D0032) with a 5 year term from the MVLWB.
2017 | De Beers announces its intent to enter into final closure of the Mine and is instructed to submit a Final CRP to the MVLWB in early 2019.

#### Extended Care and Maintenance Phase

2018 | In early 2018, the ECM plan is updated and ECM continues at the Mine.
2018 | To facilitate the transition to periods of zero occupancy at Snap Lake Mine, the land use permit is amended in June.
2019 | De Beers will submit a Final Closure Reclamation Plan and Water Licence application for closure to the MVLWB in early 2019.

### 4.3 Site Geology

As described in Section 3.2.2, the Snap Lake kimberlite dyke averages 2-3 m in thickness, and gently dips to the northeast at about 15° from its subcrop on the northwest peninsula of Snap Lake. The host rocks are predominantly granites, with the upper part of the deposit within metavolcanics. The kimberlite dyke as currently outlined, measures approximately 2,000 m along strike and extends for a vertical depth of about 560 m below ground surface. Additional geological information is provided in Section 3.2.2.

The geometry of the Snap Lake kimberlite dyke facilitated its mining using underground methods. The underground mine was accessed via a surface portal and ramp that splits into two ramps, the north and south ramps, about 780 m from the portal. The south ramp continues below the central part of the planned mining area and provides primary access to most of the mine. The north ramp accesses to the northern part of the mining area, and provides a second haulage route.

Over 60 km of drifts and ramps were developed in the subsurface to support extraction of the kimberlite dyke using a modified room and pillar mining technique. A planar overview of the existing underground as-built information is presented in Figure 4.2. Ore was hauled by diesel trucks to an underground primary jaw crusher located on the 5160 level. Crushed material was then transferred to surface for processing by a single flight conveyor.

### 4.4 Project Summary

The Mine was an underground operation, which included the underground workings, as well as surface facilities. Notable surface components include the processing plant complex, North Pile, water management structures, a water treatment plant, fuel storage facilities, roadways, an airstrip, laydown areas, and various buildings (e.g., processing plant complex, worker accommodations, etc.), as shown on the site plan presenting the current surface layout (Figure 2.2) and on the aerial photograph provided in Figure 4.3. The Project is now in an ECM phase with principal site activities including the control, treatment and discharge of contact water runoff.
The project summary that describes the current activities and infrastructures at the Mine is detailed in the following sections. The project alternatives section summarizes the alternatives analysis for the development of the project from the EA (De Beers, 2002). The project components section categorizes all existing project components into: North Pile and related water management system; underground mine workings; and site infrastructure. The current conditions of the features included in each of the mine components are described in Section 4.6.

A recent (2018) aerial view of the mine site that depicts the locations for the major mine components is provided in Figure 4.3. A map of the surface infrastructure is provided in Figure 2.2. Photographs, physical characteristics and quantities for all mine components are provided within the Snap Lake Mine Financial Security Analysis Report (Arktis, 2018c) in Appendix F.
4.5 Project Alternatives

Project alternatives were assessed during the initial mine planning stage and presented within the project EAR (De Beers, 2002). The overarching decision to limit the size of the mine footprint, if possible, was made at an early stage in the development of the Project. This decision was made entirely for environmental reasons, specifically to keep the area of disturbance to a minimum and, therefore, keep the potential effects of disturbance to terrestrial and aquatic resources to a minimum. Project design alternatives considered during initial mine design process are summarized in Table 4.1. Additional discussion of project alternatives focused on the closure approach for the Project site is presented in Section 5.2.

Additional detailed descriptions of the project alternatives are provided in Chapter 2 – Project Alternatives and Opportunities of the Project EAR (De Beers, 2002).
### Table 4.1 Project Alternatives Considered during the EA and the Selected Options

<table>
<thead>
<tr>
<th>Project Design Aspect</th>
<th>Alternative</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Mining Approach</strong></td>
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<tr>
<td>Large Open Pit</td>
<td></td>
<td>A large open pit mine extending across most of the peninsula allowing maximum extraction of the resources located on the northwest peninsula.</td>
</tr>
<tr>
<td>Small Open Pit</td>
<td></td>
<td>A small open pit mine, allowing less than one third of the resource extraction of the large open pit option.</td>
</tr>
<tr>
<td><strong>No Open Pit, underground mining</strong></td>
<td></td>
<td>No open pit mine with all of the reserve mined from underground. This option was selected because dust, noise, and waste rock impacts were reduced. The initial plan suggested that approximately half of the waste rock would be returned for disposal underground, thereby reducing long-term impacts on the northwest peninsula; however this was not implemented during mining (see ‘Kimberlite Management’ below in table). This selected alternative did not have the lowest initial cost.</td>
</tr>
<tr>
<td>Underground Mining Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift and fill</td>
<td></td>
<td>This method was considered as an alternative method to be used if conditions (mainly dyke geometry) precluded the use of the room and pillar method.</td>
</tr>
<tr>
<td><strong>Modified room and pillar with end slicing</strong></td>
<td></td>
<td>Several underground mining methods over the LOM were proposed and evaluated over the LOM in an effort to improve performance. This method was selected as it had the combination of operational flexibility, geotechnical stability, and cost effectiveness. It is a mining method flexible enough to deal with the dyke complexities that were observed during the advanced exploration program.</td>
</tr>
<tr>
<td>Inclined room and pillar</td>
<td></td>
<td>These methods were rejected primarily because of potential difficulties in responding to variable dyke geometry, which would result in poor control of mining dilution and recovery.</td>
</tr>
<tr>
<td>Longhole</td>
<td></td>
<td>This method was rejected primarily because of the difficulty in using mobile equipment and the need to use labour-intensive jackleg drilling and slasher mucking.</td>
</tr>
<tr>
<td>Longwall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Pile Processed Kimberlite Pile and South Processed Kimberlite Pile</td>
<td></td>
<td>Surface depositing of all waste, with the current North Pile as well as a South Pile located where the current water management pond is located.</td>
</tr>
<tr>
<td><strong>North Processed Kimberlite Pile and Underground Storage</strong></td>
<td></td>
<td>Surface deposition of approximately 50% of the PK in the North Pile, with 50% of the PK to be deposited underground. This option was selected to reduce long-term impacts on the northwest peninsula. This option was later revised (2014) to abandon underground deposition of PK due to various technical difficulties. Subsequently all PK was deposited on surface in the North Pile. Additional discussion of North Pile design alternatives is provided in Section 4.6.1.1.</td>
</tr>
</tbody>
</table>
### Project Design

<table>
<thead>
<tr>
<th>Project Design Aspect</th>
<th>Alternative</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Management</td>
<td><em>Water Treatment Plant (WTP)</em></td>
<td>A water treatment plant that would treat water from the waste rock piles and the underground. The selection of the WTP was based on achieving the best practical discharge limits that would in turn comply with specific ambient water quality objectives set for Snap Lake.</td>
</tr>
<tr>
<td></td>
<td>Sedimentation Ponds</td>
<td>A sedimentation pond would be constructed for processed kimberlite piles, and then discharge into Snap Lake</td>
</tr>
<tr>
<td>Energy Sources</td>
<td><strong>Diesel</strong></td>
<td>Diesel generators that provide all the power for the facility. This option was selected as the solar, wind and fuel cell alternatives were not considered viable due to cost, climatic conditions, and/or the commercial availability of equipment required to meet the Project’s needs. Although propane use would result in lower emissions and operating costs, diesel was selected due to the reliability of supply and safety on the winter road.</td>
</tr>
<tr>
<td></td>
<td>Wind Turbines</td>
<td>Diesel generation as primary power source, with a secondary power source of wind turbines.</td>
</tr>
<tr>
<td></td>
<td>Solar Power</td>
<td>Diesel generation as primary power source, with a secondary power source of photovoltaic cells.</td>
</tr>
<tr>
<td></td>
<td>Fuel Cell</td>
<td>Diesel generation as primary power source, supplemented by a fuel cell power plant.</td>
</tr>
<tr>
<td></td>
<td>Propane</td>
<td>Diesel generation as primary power source, with propane fired heaters for heating the underground mine ventilation air in the winter.</td>
</tr>
</tbody>
</table>

**Note:** The selected alternative has been identified with bold and italic formatting.

### 4.6 Project Components

The Project site has been divided into three primary mine components which include: the North Pile and its related water management systems, the underground mine, and surface infrastructure (Table 4.2). The infrastructure mine component includes all mine areas, water management structures and facilities at surface with the exception of the North Pile, and points of access to the underground mine (e.g., portals, raises). These three categories along with their individual components are described in the following subsections. A site plan depicting the surface features of the Mine is provided in Figure 2.2. As-built drawings of individual mine components are available upon request.

#### 4.6.1 North Pile and Related Water Management Systems

The North Pile facility is the engineered, permanent surface storage facility for mine waste rock and PK produced during the operating life of the mine. The location and current layout of the North Pile and related features is presented in Figure 4.4.
Figure 4.4    North Pile Current Configuration

Source: Golder (2018f)
### Table 4.2 Mine Components for Closure Planning

<table>
<thead>
<tr>
<th>Mine Component</th>
<th>Description and Photograph Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North Pile and Related Water Management Systems</strong></td>
<td>Includes the surface disposal facility embankments, engineered cover, and all waste materials deposited within. Also includes the associated sumps and water management structures.</td>
</tr>
<tr>
<td>Starter Cell</td>
<td>Appendix F, Figures 72-85</td>
</tr>
<tr>
<td>East Cell</td>
<td>Appendix F, Figures 64-71</td>
</tr>
<tr>
<td>West Cell</td>
<td>Appendix F, Figures 47-63</td>
</tr>
<tr>
<td>North Pile Internal Drainage</td>
<td>Appendix F, Figures 64-70; 77-82</td>
</tr>
<tr>
<td>Perimeter Water Control Structures</td>
<td>Appendix F, Figures 89,90; 92-97</td>
</tr>
<tr>
<td>Water Management Pond</td>
<td>Appendix F, Figures 87,88</td>
</tr>
<tr>
<td><strong>Underground Mine Workings</strong></td>
<td>Includes flooded mine workings, underground water pumping system, and portal and raise openings.</td>
</tr>
<tr>
<td>Mine Portals</td>
<td>Appendix F, Figure 178</td>
</tr>
<tr>
<td>Raises</td>
<td>Appendix F, Figure 134</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td>All constructed surface features, materials and works except for the North Pile and its related water management structures. Includes buildings and equipment, laydown areas, pads and stockpiles, piping, airstrip, roads, pits and quarries, and waste management facilities.</td>
</tr>
<tr>
<td><strong>Surface Facilities and Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>Processing Plant Complex</td>
<td>Appendix F, Figures 174-177, 179-207</td>
</tr>
<tr>
<td>Water Treatment Plant and Utilities Building</td>
<td>Appendix F, Figure 91</td>
</tr>
<tr>
<td>Potable Water Treatment Plant</td>
<td>Appendix F, Figure 156 (temporary potable WTP)</td>
</tr>
<tr>
<td>Sewage Treatment Plant</td>
<td>Appendix F, Figure 109 (STP1)</td>
</tr>
<tr>
<td>Freshwater Intake and Pumphouse</td>
<td>Appendix F, Figures 112-188</td>
</tr>
<tr>
<td>Treated Water Outfalls</td>
<td>Appendix F, Figures 171-173</td>
</tr>
<tr>
<td>Fresh Air Intake Fans</td>
<td>Appendix F, Figures 134-139</td>
</tr>
<tr>
<td>Batch Plant and Maintenance Shop</td>
<td>Appendix F, Figures 153-163</td>
</tr>
<tr>
<td>Emulsion Plant</td>
<td>Appendix F, Figures 14-22</td>
</tr>
<tr>
<td>AN Storage Facility</td>
<td>Appendix F, Figures 23-24</td>
</tr>
<tr>
<td>Airstrip Area Buildings</td>
<td>Appendix F, Figure 31</td>
</tr>
</tbody>
</table>
4.6.1.1  Design Considerations/Alternatives

At the initial mine planning stage, the primary alternatives affecting closure that were evaluated for the design of the North Pile facility included:

- Underground disposal of processed kimberlite; and
- Variation of pile footprint and height.

Within the EAR, it was estimated that approximately 47% of the processed kimberlite could be placed back underground in the mined-out workings as paste backfill, with the remainder of the processed kimberlite disposed of on the ground surface (De Beers, 2002). Due to swell factors it was not considered possible, or practical, to place all of the PK back into the underground mine. Thus, two primary alternatives were considered for deposition of both PK and waste rock in the North Pile. The first alternative was a relatively high pile, which had a smaller area but greater visual impact. The second alternative included a larger footprint, which would result in a much lower pile. The first option was eliminated to minimize any visual impacts of the pile profile on the landscape.

During development of the ICRPv1 (AMEC, 2006), three more detailed alternatives were considered for the footprint of the North Pile. Options considered are presented in Table 4.3, and include variable height and footprint combinations.
Table 4.3  2006 North Pile Design Options

<table>
<thead>
<tr>
<th>Waste Pile Characteristics</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crest Elevation (masl)</td>
<td>479</td>
<td>484</td>
<td>497</td>
</tr>
<tr>
<td>Height Above Lowest Land Form (m)</td>
<td>35</td>
<td>39</td>
<td>52</td>
</tr>
<tr>
<td>Height Above Highest Land Form (m)</td>
<td>-5</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Pile Visibility</td>
<td>Lowest</td>
<td>Moderate</td>
<td>Highest</td>
</tr>
<tr>
<td>Foot Print (ha)</td>
<td>126</td>
<td>92</td>
<td>69</td>
</tr>
<tr>
<td>Perimeter Length (m)</td>
<td>5,600</td>
<td>4,200</td>
<td>3,200</td>
</tr>
</tbody>
</table>

In general, for the same stored volume, a smaller footprint would have lower costs for embankment construction, material placement, surface water control and closure. However, the greater height of the smaller footprint option would result in greater visual impact. In the case of Option 3, the smaller footprint results in a crest would be approximately 13 m above the highest surrounding landform (484 masl). Options 1 and 2 have similar pile visibility.

Option 1 had the largest footprint area, about 37% larger than Option 2 and 83% larger than Option 3, and the longest perimeter. A larger footprint increases the amount of surface water run-off and the quantity of sediment to be collected. Minimizing the perimeter length reduces the length of interception ditches, distribution pipework and minimizes the embankment requirements. Option 2 had a pile height consistent with the surrounding landforms and moderate visibility, footprint and surface area. Options 2 and 3 sequentially require less material for containment shell construction than Option 1; however, Option 2 was considered more favourable than Option 3 as it does not exceed the height of the surrounding land.

Option 3 was eliminated in order to minimize any visual impacts of the pile profile on the landscape. Option 1 was later eliminated considering the excessive footprint and the requirement of significantly more material for construction of an engineered cover at closure. Option 2 was considered to offer the best compromise between visibility, cost and disturbed area, and was the approach selected by De Beers.

Option 2 provided flexibility for storage of PK materials within a relatively moderate footprint size and without exceeding the maximum landform elevation. Depending on the final grading plan, Option 2 allowed between approximately 9 and 19 million m$^3$ of PK and waste rock materials to be contained without exceeding the height of nearby landforms. This option formed the basis for design of the North Pile.

In 2014, due to various technical difficulties in the production and deposition of PK paste, plans to backfill the underground mine with PK were no longer considered practical. Although critical design and construction decisions had been implemented that limit any significant modifications concerning the North Pile footprint, height, and design, potential expansion options were considered in light of the requirement for increased volumes of PK to be deposited on surface rather than underground. These were then dismissed upon entering ECM.
4.6.1.2 North Pile Development History

The North Pile was developed in phases to accommodate waste rock and PK materials produced during mining, and consists of the Starter Cell, East Cell, and West Cell. The West Cell was not fully developed, and was not used for mine waste deposition.

In general, the North Pile construction includes perimeter embankments, internal rib berms and a network of water control structures. The perimeter embankments are constructed of non-PAG waste rock and PK materials (Golder, 2008).

Pre-development, the site selected for the North Pile had a thin discontinuous cover of organic and mineral soil over granite bedrock. The organic layer in the embankment zone was stripped, and a starter berm was constructed of non-PAG rock to provide containment for the North Pile.

The Starter Cell, with relevant water control structures, was constructed between 2005 and 2007. PK was deposited within the Starter Cell between 2008 and 2015. At the close of 2015 when C&M commenced, the Starter Cell was nearing capacity.

Construction of the East Cell, including interception ditches, commenced in 2008. Construction continued into 2015 in order to raise East Cell berms until they reached the design elevation. PK deposition in the East Cell started in 2012 and continued into 2015.

A seepage collection system, which consists of water control structures such as ditches and sumps, is incorporated into the North Pile design to collect runoff and internal seepage from the North Pile, and to convey the water to the water treatment plant before it is discharged to Snap Lake. A grout curtain was also constructed as a method to limit the flow of water from Snap Lake into the perimeter water control structures. Additional discussion of the water control structures associated with the North Pile is provided under the Water Management System heading below.

In addition to PK and waste rock, the North Pile facility incorporates a disposal facility for non-hazardous wastes. The initial location of the landfill was in the Starter Cell. In 2012, landfilling in the Starter Cell ceased due to the Starter Cell approaching capacity, and a new landfill was commissioned in the East Cell, as approved by the MVLWB.

4.6.1.3 North Pile Components

The following descriptions of the North Pile components were presented in Golder (2018f).

Starter Cell

The Starter Cell is located within the southern portion of the North Pile and was constructed as eight sub-cells: Cells A, B, C, D, E, F, SQ, and LF. Rib berms and perimeter embankments separate each sub-cell and were constructed using the combined coarse and grits PK, and/or waste rock materials. Cell LF was historically used for the disposal of landfill waste material. The remainder of the cells were used to store deposited PK material. Part of the storage capacity for the cell was provided by quarrying and removing granite rock for general site construction use.
East Cell

The East Cell is located within the northern portion of the North Pile and was constructed in five sub-cells: Cells 1, 2, 3, 4, and 5. Rib berms and perimeter embankments separate each sub-cell and were constructed using the combined coarse and grits PK, and/or waste rock materials. Cell 1 is currently used for the disposal of landfill waste material. Cells 2, 3, 4, and 5 were used to store deposited PK material.

West Cell

The West Cell area is located adjacent to the East and Starter Cells of the North Pile. Construction of the Well Cell berms and perimeter water control structures began in 2015, but were never completed due to the entry of the mine into C&M. The current configuration in the West Cell area includes the partial West Cell divider dyke, constructed of waste rock and PK, and a ditch that drains towards Sump 5. A landfarm was constructed in the southeast corner of the cell area for managing hydrocarbon contaminated soils (see Section 4.6.3.7).

The West Cell was intended to encompass the west perimeter embankment of the East and Starter Cells, which was constructed as a future internal berm at approximately 1.5H:1V, providing structural support to ensure its long term stability. Since the West Cell was not fully developed, the west perimeter embankment was left exposed and will require interim and final closure measures to be undertaken to ensure the future stability of the West perimeter embankment. These measures are described in Chapters 5.

4.6.1.4 North Pile Water Management System

The current water management system for the Snap Lake Mine is described in the Extended Care and Maintenance Water Management Plan (De Beers, 2018d), approved by the MVLWB under Water Licence MV2011L2-0004. The overall objective of the plan is to manage water quantity and quality to minimize potential impacts to the aquatic environment from the Mine. The water management system includes systems and related infrastructure to collect, store, treat and discharge mine contact water (i.e., water that has been exposed to mine rock, including the mine workings, PK and waste rock), and to provide a fresh water supply and manage sewage as required for site operations.

The components for the North Pile water management system for mine contact water are displayed in Figure 4.4 and are summarized as follows:

- Internal water control structures and ponds within the North Pile.
- Perimeter Water Control Structures (PWCS): Perimeter ditches to intercept North Pile seepage and external mine contact water runoff, and five sumps to collect water from the perimeter ditches and water decanted from the North Pile. Sump 3 and Sump 5 are equipped with pumping systems to transport contact water through pipelines to the water management pond and water treatment plant.
- The Water Management Pond to provide temporary storage for mine water prior to treatment at the Water Treatment Plant and subsequent discharge into Snap Lake.
Additional water management facilities required for site operations are described further in the Infrastructure section (4.6.3), and include:

- Water Treatment Plant (WTP) and reverse osmosis water treatment plant (RO-WTP) to allow for treated mine water to meet water quality criteria prior to discharge to Snap Lake via a diffuser assembly.
- Fresh water supply, including a pump house at Snap Lake and a Potable Water Treatment Plant;
- Sewage collection system with Sewage Treatment Plant; and
- Ancillary infrastructure, including pipelines, sumps, diversion ditches and site grading to convey water throughout the mine water management system.

Water management related to the North Pile is required seasonally during ECM, from the spring freshet until freeze-up. Figure 4.5 shows the water management system at the North Pile, including the perimeter sumps, and very little water ponded within the North Pile cells in July, 2018.

**Figure 4.5 Aerial View of the North Pile, Showing Water Management**

![Aerial View of the North Pile, Snap Lake Mine](image)

Source: Golder (2018c)

*Note: SP# is perimeter sump; TS# is temporary sump.*

**North Pile Internal Drainage**

Within the North Pile, surface runoff pools against the rib berms and perimeter embankments during the open water season. Under ECM, the site operations team actively monitors and pumps this water off the pile and into the sumps of the PWCS. Standpipe piezometers throughout the North Pile support the monitoring of water levels in determining pumping requirements (Golder, 2018c). Ponded water levels in the interior cells of the Starter Cell are generally very low or dry (Golder, 2018c). Shallow ponding was observed in 2018 and in previous years near the centre of Cell LF (Figure 4.5); this was not considered to be a concern and is noted to be monitored to determine the requirement for ponded water in Cell LF to be
pumped to the PWCS (Golder, 2018c). Within the East Cell, ponded water is pumped internally from Cell 4 to Cell 5, and water is removed from the North Pile, primarily from Cell 3 and Cell 5 by pumping to the PWCS (e.g., Sump 3) on an as needed basis (Golder, 2018c).

Perimeter Water Control Structures

The North Pile PWCS, comprised of ditches and sumps, intercept and collect runoff and seepage from the North Pile and contact water runoff from the surrounding area for pumping to the WMP. The PWCS ditch flow directions are topographically controlled to provide gravity flow to the sumps. The sumps enable pumping of water to the WMP, and are dewatered on an as-needed basis during the open water season to maintain minimum practicable water levels. During ECM, the pumps in the sumps are removed just prior to the winter and are reinstalled in April/May, prior to the spring freshet.

The runoff and seepage from the North Pile area is controlled to prevent it from reporting to the downstream environment. The perimeter ditches and sumps are HDPE-lined to limit seepage losses. The northern portion of the ditch along the shoreline was constructed to promote positive flow of water from Snap Lake towards the ditch to reduce the risk of seepage from the North Pile entering Snap Lake.

All water from the North Pile is diverted to the WMP and then treated, if required, at the WTP in compliance with Water Licence MV2011L2-0004.

Water Management Pond

The WMP receives water from the North Pile sumps, mine catchment area (i.e., surface water runoff), processing plant complex (when operational), and the sewage treatment plant. The WMP was created by two dams that were constructed in 2000. The dams consist of a rock fill embankment supporting an 80-mil textured HDPE liner on the upstream side. The liner is tied into the underlying intact bedrock (using a mixture of sand and powdered bentonite) and compacted into a key trench to minimize the seepage beneath the dams. Suitable granular bedding and cover layers were placed on either side of the liners. Small seepage losses from the WMP are expected and were scoped during the Environmental Assessment for the project. In 2017, during ECM, no visible seepage was observed at WMP Dam 1, and it was not possible to directly observe seepage from Dam 2 due to cover by the haul road and a laydown area (Golder, 2018d). The quality of potential seepage from the WMP dams is monitored via monitoring wells SNP-02-11, -12 and -13B.

As described in Section 4.2, the original purpose of the WMP was for processed kimberlite containment, and during the AEP, water from the underground workings and processed kimberlite were stored in the PKC facility. The PK deposited in this facility remained in place when it was repurposed for water management during mine operations and the C&M phases. It is assumed that no more than 40,000 tonnes, the volume of the AEP bulk sample, of PK are deposited in the WMP.

In general, natural drainage for the processing plant complex and vicinity flows from a local topographic high, east of the mine portal, and collects in the WMP to the west of the processing plant area. Grading within the natural catchment area is designed to collect and promote positive drainage towards the WMP. Water that has not interacted with PK or waste rock is considered non-contact water and diverted directly to the receiving environment.
4.6.2 Underground Mine Workings

4.6.2.1 Flooded Workings

The underground mine component includes the underground workings (ramps, drifts, shafts and raises). In early 2017, as part of ECM, reclamation activities were carried out to remove major structures and equipment and all hazardous materials from the underground mine workings (De Beers, 2017f). The workings were then flooded, starting on February 9, 2017, as part of ECM, and the workings were fully flooded within four months.

4.6.2.2 Underground Water Management

A water pumping system is currently in place to pump mine contact water from surface for disposal at the lowest practical level within the mine. This measure, which is described in the approved ECM Plan (De Beers, 2018d), provides additional capacity contingency to reduce impacts on the environment and to meet Water Licence effluent quality criteria. Surface waters were pumped underground between March 23, 2017 and May 16, 2017, again between July 29, 2017 and November 5, 2017 and June to October 2018. Surface waters will continue to be pumped underground as needed throughout closure.

4.6.2.3 Mine Portals

One access portal and one conveyor portal are located on the northwest peninsula about 200 m east of the processing plant. These portals have been temporarily secured to prevent access.

4.6.2.4 Raises

In addition to the two mine portals, other openings to the underground mine include two fresh air raises and a return air raise. The fresh air raises are located on the peninsula, northeast of the portals, and are covered by fan structures. One return air raise is located on the north shore of Snap Lake, approximately 500 m from the plant site, with a steel-reinforced concrete collar placed at the surface.

Table 4.4 summarizes the underground mine openings at the site.

<table>
<thead>
<tr>
<th>Mine Opening</th>
<th>Dimensions</th>
<th>UTM Easting</th>
<th>UTM Northing</th>
<th>Comment</th>
<th>Photograph Reference*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Portal</td>
<td>Approx. 8 m wide x 5 m high</td>
<td>506700</td>
<td>7052980</td>
<td></td>
<td>Figure 162, 163</td>
</tr>
<tr>
<td>Conveyor Portal</td>
<td>8.5 m wide x 5.0 m high</td>
<td>506642</td>
<td>7052914</td>
<td>A 5 m high vertical raise for the mine dewatering piping system opens from the conveyor ramp approximately 35 m northeast of the portal - located at underground services building #62.</td>
<td>Figure 178 (portal); Figure 168 (underground services building)</td>
</tr>
</tbody>
</table>

Table 4.4 Summary of Mine Openings
### Mine Opening Dimensions

<table>
<thead>
<tr>
<th>Mine Opening</th>
<th>Dimensions</th>
<th>UTM Easting</th>
<th>UTM Northing</th>
<th>Comment</th>
<th>Photograph Reference*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh Air Raise 1 (FAR 1)</td>
<td>3.5 x 4.0 m</td>
<td>507080</td>
<td>7053105</td>
<td>-</td>
<td>Figure 134, 136</td>
</tr>
<tr>
<td>Fresh Air Raise 2 (FAR 2)</td>
<td>3.5 x 4.0 m</td>
<td>507077</td>
<td>7053092</td>
<td>Emergency egress at FAR2</td>
<td>Figure 134, 139</td>
</tr>
<tr>
<td>Return Air Raise 1 (RAR 1)</td>
<td>3.5 x 3.5 m</td>
<td>507550 (estimated)</td>
<td>7053900 (estimated)</td>
<td>The return air raise is located on the north side of Snap Lake, approximately 500 m NE of the main Mine area</td>
<td>-</td>
</tr>
</tbody>
</table>

* See Appendix F (Financial Security Analysis Report).

### 4.6.3 Infrastructure

#### 4.6.3.1 Surface Facilities and Equipment

Surface facilities and infrastructure are illustrated in the site plan (Figure 2.2) and the labeled aerial photo presented in Figure 4.3.

Locations as well as photographs, physical characteristics and quantities for the mine components detailed below are provided within the Snap Lake Mine, Financial Security Analysis Report (Arktis, 2018b) in Appendix F. Appendix G.1 also includes an inventory of the Buildings and Equipment that are included in the Demolition Plan (refer to Section 5).

Existing surface infrastructure includes the following major components/areas:

- Processing Plant Complex;
- Fresh water and wastewater treatment facilities;
- Batch Plant and Maintenance Shop area:
- Ammonium nitrate (AN) storage and bulk emulsion plant;
- Airstrip-related structures and laydown areas; and
- Bulk Fuel Storage Compound with approximately 45 ML diesel storage capacity, along with associated containment, fuel transfer and dispensing systems.

Ancillary surface infrastructure that supports site operations includes:

- Warehouse and storage buildings;
- Laydown and freight storage areas constructed of compacted fill for temporary storage of equipment and materials;
- Oil-fired incinerators;
- Vehicle parking areas;
• Site electrical distribution system (utilities);
• Water/wastewater, and fuel pipelines; and
• Surface mobile equipment.

The Snap Lake Mine currently requires its own support facilities and depends on regular shipments of consumables and materials over the annual winter road and aircraft (year-round).

**Processing Plant Complex**

The processing plant complex is located south of the portals, and includes the following major components:

• **Processing Plant:** Enclosed steel building structure on concrete foundations housing the crushing, washing, screening, conveying, pumping, cycloning, dense media separation and recovery equipment;
• **Coarse ore storage and reclaim facility:** consisting of a cladded steel A-frame structure, belt conveyors and ore reclaim equipment, all supported on concrete foundations;
• **Service Complex:** enclosed steel structure on concrete foundations that houses the mine dry, offices and administration facilities, repair shops, laboratory, first aid facilities and warehouse;
• **Utilities Building:** enclosed steel structure on concrete foundations housing a battery of diesel generators, heat recovery equipment, boilers for glycol-based heat distribution system, and auxiliary power generation and electrical distribution equipment. The fresh water and waste water treatment plants are adjacent to the Utilities Building;
• **Accommodations Complex:** interconnected steel and wooden structures on piled footings housing dormitory rooms and common facilities such as kitchen and eating areas, food storage, and recreation facilities;
• **Ancillary infrastructure:** Storage, warehouse and maintenance buildings with seacans and laydown areas.

Sheltered tunnels allow for pedestrian traffic between buildings while protecting workers from the elements. North and west of the underground portals, there are additional areas containing shops, maintenance buildings, offices and temporary storage and laydown areas. The projects office is located near the Processing Plant Complex, on the north side of the conveyor portal.

Processing plant complex facilities, including the processing plant, not required for ECM are currently shut down in a dormant state.

**Water Treatment Plant**

During operations and early C&M activities, water from the WMP was treated at the Water Treatment Plant (WTP) for processing before being returned to Snap Lake after meeting environmental regulations. A large proportion of the water requiring treatment produced from underground mine dewatering, which ceased upon the flooding of the mine in 2017.

The WTP water treatment process, with a nominal capacity of 35,000 m$^3$/day, included coagulation (using ferric sulphate), flocculation and pH control (using sulphuric acid, as required) within a reactor tank,
followed by settling out TSS within a thickener tank and subsequent filtration prior to recycling within the Mine site or discharge to Snap Lake.

A second, reverse osmosis water treatment plant (RO-WTP) was commissioned in 2018, and is located on the east side of the WMP. The modular RO-WTP unit provides standalone, supplemental water treatment capacity, and works with the existing water treatment in-line monitoring and valve interlock mechanism. The RO-WTP utilizes a pressure driven membrane filtration to treat wastewater. The contaminants targeted for removal include nitrates and TDS. The expected treatment efficiency of the RO retrofit is approximately 90%. While fully operating, the RO plant is capable of generating approximately 750 m$^3$/day of brine. Permeate (clean water) from the RO treatment is discharged to Snap Lake via the diffuser provided all effluent quality criteria are met as per the water license. Waste brines generated by the RO treatment process is discharged to the underground via an existing pipeline. A contingency to this process is to discharge the brine to the North Pile facility.

The water treatment system is set up in a way that some process modules can be bypassed if determined that the influent water quality does not require additional treatment to achieve the effluent quality criteria.

**Potable Water Treatment Plant**

Raw water is pumped from Snap Lake by overland pipeline to the Potable Water Treatment Plant. Water is treated with ultra-violet light for disinfection, chlorinated and stored in a storage tank in the Potable Water Treatment Plant. Treated water is piped to limited areas requiring potable water during ECM and closure activities.

**Sewage Treatment Plant**

An Activated Sludge Treatment plant with one Cx9 external membrane designed for a maximum capacity of 135 m$^3$/day is located in a fold-away building adjacent to the east of the North Pile. This plant with one membrane required the installation of automatic pre-filters, one membrane feed pump, and one membrane circulation pump. The modular design allows the plant to be relocated as necessary.

At the final stage of the process, liquid that meets discharge criteria set out in the Water License MV2011L2-0004 is decanted as effluent and pumped to the WMP, where is mixes with mine contact water for subsequent treatment at the Water Treatment Plant prior to release to Snap Lake. Biosolids produced during sewage treatment are dewatered, bagged and disposed of in the North Pile landfill. The landfill is covered to prevent the spread of debris, while any runoff from the landfill reports to the sumps in the same manner as other runoff from the North Pile.

Due to the reduction in personnel during Care and Maintenance, a smaller Wastewater treatment plant (STP3) was installed and commissioned in 2018. The sewage entering STP3 is treated with chlorine only, utilizing an average of 25 L per month while operating.

**Freshwater Intake and Treated Water Outfalls**

A freshwater intake is located at the shore of Snap Lake, north of the Mine, to withdraw water from the northwest arm of the lake. A pumphouse located adjacent the shore contains the freshwater pumping equipment.
Two discharge water outfalls (one main pipeline and one backup pipeline) are located on the eastern shoreline of the northwest peninsula. The submerged pipelines are weighted to sit slightly above the substrate of the lake bottom and extend approximately 125 m out from the shore. At the end of the pipelines, there is a 60 m long diffuser structure with five evenly spaced outlet ports.

**Fresh Air Intake Fans**

Fresh air intake fans are installed on surface at the two intake ventilation raises, complete with diesel-fired air-heating units enclosed in steel structures on concrete foundations.

**Batch Plant and Maintenance Shop**

The batch plant and maintenance shop are accessed to the east of the main fuel storage compound. This area also includes the Tli’ Cho Shop, a laydown area and core storage pads.

**Emulsion Plant**

The emulsion plant area is located approximately 1.3 km west of the main Mine area. The emulsion plant pad, which is HDPE-lined, contains an emulsion plant and bulk plant building, in addition to ancillary structures and fuel storage.

An ammonium nitrate (AN) storage pad was previously located adjacent to the northeast of the emulsion plant pad, with a central sump designed to receive contact water drainage from both the AN storage pad and emulsion plant. Bags of AN were stockpiled at this AN storage pad; however, elevated levels of nitrate, nitrite and ammonia were detected in surface water at surveillance network program (SNP) locations surrounding the emulsion plant area, and concerns regarding bag deterioration due to outdoor exposure and inadequate capture of contact water in 2008 (Arktis, 2013). Temporary corrective measures were undertaken (e.g., regrading), and all AN storage bags were subsequently relocated to the enclosed AN storage facility (described below) in 2009 (Arktis, 2013). The AN storage pad was reclaimed in August-October 2011 by completely removing the pad material and liner down to the original ground surface. Analytical results of confirmatory soil sampling met the applicable guidelines and no further soil excavation was completed. It was additionally determined in 2012 that the surface granular fill at the emulsion plant pad and sump were not likely a source of AN contamination (Arktis, 2013).

**AN Storage Facility**

The AN storage area is located approximately halfway between the emulsion plant and the main Mine site. An AN storage building and several seacans are present in this area.

**Airstrip Area Buildings**

The airstrip is supported by the Airport Winter Haven Building, and several ancillary structures (e.g., seacans, trailers and a weather station).
4.6.3.2 Pads and Stockpiles

Laydown Areas and Gravel Pads

The main laydown area and a truck parking area are located in the general vicinity of the airstrip. Other small laydown and parking areas for vehicles and mobile equipment are located throughout the Mine site. Laydown and parking areas are identified in Figure 2.2.

Two kimberlite storage pads are located southwest of the process plant. There is no unprocessed kimberlite ore stockpiled on surface.

A 60-mil HDPE lined de-icing pad is located adjacent to the north of the airstrip.

Essential repair and replacement parts are generally stocked at the airstrip laydown area. Consumables required in relatively small quantities that are not listed include, but are not limited to, the following items:

- Equipment maintenance parts.
- Shop supplies (batteries, hardware, fasteners, solvents, machining lubricants, etc.);
- Camp maintenance products (detergents, cleaning fluids and powders, light bulbs, etc.); and
- Office supplies.

Stockpiles

A storage area for quarried granite, with an estimated volume of 11,200 m$^3$ (Golder, 2018a), is located adjacent to the quarry site and crusher (located between the North Pile and the airstrip area to the south). An organics stockpile with an estimated volume of 147,000 m$^3$ (Golder, 2018a) is located adjacent the main laydown area east of the airstrip.

Fuel storage areas

The primary fuel storage area at the Mine is located north of the main portal and includes the Fuel Storage Compound, which consists of three 12,780,000 L and one 10,000,000 L above ground storage tanks containing diesel, as well as twelve 330,000 L diesel tanks in a tank farm, and a temporary fuel storage area. An above ground piping network is used to transfer fuel to the major infrastructure throughout the site. Secondary fuel tanks are located in various areas around the Mine, such as near the airstrip, fresh air raise and diesel generators.

All fuel storage and transfer areas contain spill containment features, such as double-walled tanks, dykes/berms and/or concrete pads with sumps. The current fuel storage tank inventory is summarized in Appendix G.1, and locations of the main fuel storage areas are identified in Figure 2.2.

4.6.3.3 Piping

On-surface and buried piping is utilized throughout the Mine site to transport mine contact water, fresh and waste water, and fuel. The piping network is shown in Figure 2.2.
4.6.3.4 Transportation Routes

Airstrip

The airstrip is located approximately 1.5 km west of the processing plant complex (Figure 4.3, Figure 2.2). The airstrip is approximately 1,900 m in length and 45 m wide. The total cleared and graded area is roughly 150 m wide to accommodate fully loaded C-130 Hercules and Boeing 737 or equivalent aircraft. The airstrip is equipped with a non-directional beacon and air radio. Approach lighting is installed for nighttime and winter operations. A small air terminal building and a weather observation facility is located adjacent to the apron. One fuel tank has been installed for generator fuel storage.

Site Roads

Primary roads on-site are two lanes with an 8-m surface and 1-m shoulders. Where feasible, service roads are single lane with a 4 m surface and 0.5 m shoulder. Road grades are 8% maximum with lesser grades used wherever possible. Road beds have been developed using rockfill material obtained from the site.

Winter Access Spur Road

Annual re-supply for the mine is completed by truck operation over the Tibbitt-Contwoyto Winter Road, north from the end of the Ingraham Trail, east of Yellowknife. A 35-km long winter access spur road is constructed by De Beers each winter to connect the Mine to the Tibbitt-Contwoyto Winter Road at approximately km 222 (km 0 of the winter road is Tibbitt Lake at the departure from the Ingraham Trail) near MacKay Lake. Sections of the access spur road are over-land, and have been developed with a road bed.

4.6.3.5 Pits and Quarries

Historical Bulk Sample Pits

Two bulk sample pits were excavated during advanced exploration operations. The South Pit (generally referred to as ‘the’ bulk sample pit is located towards the northeast end of the peninsula (Figure 2.2). The historical bulk sample pit is approximately 20 m by 40 m in size). It is accessed via a ramp and is currently flooded.

The North Pit was located at the current site of a core pad adjacent to the north of the Batch Plant and Maintenance Shop area. During the AEP, approximately 9,000 m³ of material was removed from this pit. In 2006, the North Pit was infilled to blend with the natural surface grade using metavolcanic waste rock.

Quarries

Two granite quarries were operated during the construction and initial mine operations, and have since been covered by the North Pile, as illustrated in Figure 4.6. A third granite quarry was planned within the West Cell footprint of the North Pile; however quarrying was not carried out (Figure 4.6).
During the construction period, quarried materials were used for construction fill (e.g., airstrip, roads, backfill for concrete foundations, etc.) and production of concrete for equipment and building foundations. Granite usage during operations includes capping of North Pile for closure, crushed rock for production of concrete for underground support pillars, and crushed rock for maintenance of roads.

The West Cell Airstrip Quarry is located north of the airstrip, as illustrated in Figure 4.7. This quarry was previously operated until the Mine entered into Care and Maintenance in December 2015. From the 2015/2016 De Beers topographic data, an estimated area of 3.0 ha and average depth of 4 m was obtained for the area that has been quarried to date.

In addition to the available quarry resources, there are also existing stockpiles of rockfill material available on the surface, located at the crusher area (estimated 11,200 m³) and within sump PS5 (estimated 68,200 m³) (Golder, 2019a, Appendix H.1).
4.6.3.6 Waste Management Facilities

Measures are implemented to reduce, reuse and recycle waste. Additional information on waste management is available in the Waste Management Plan (De Beers, 2019a). The waste management system on-site incorporates two oil-fired incinerators, a waste storage building, and a landfill site within the North Pile area. A landfarm area has been developed in the West Cell area adjacent to the west of the North Pile with an impermeable liner; this area has previously been used for waste oil storage and non-hazardous waste landfilling, but no landfarming of hydrocarbon contaminated materials has taken place.

Landfill

Non-hazardous waste is deposited in the landfill located in Cell 1 of the East Cell, and includes only those approved waste materials identified in the Waste Management Plan (De Beers, 2019a). As part of waste material management services, the material is regularly buried with a cover of PK to minimize exposure to
wind and wildlife. The remaining landfilling capacity in Cell 1 and Cell 2 is estimated to be 114,000 m³ (Golder, 2019a, Appendix H.1).

Historical landfilling occurred in Cell LF of the Starter Cell.

**Incinerators and Waste Transfer Storage Area**

Two oil-fired incinerators are operated as required for the incineration of non-hazardous combustible waste materials. The incinerators and an adjacent burn pit are located south of Sump 1. Incinerator ash is tested regularly as per Environment Canada’s specifications to confirm disposal standards are met, collected in containers and transported to the solid waste disposal facility for disposal.

Waste products are sorted (non-hazardous, recyclable, etc.) and placed in suitable containers within the designated waste transfer storage area. Non-hazardous waste is deposited in the North Pile landfill area, and other waste is stored for eventual backhaul to suitably licensed off-site disposal or recycling facilities.

**Chemical Storage**

An inventory of chemicals currently stored at the mine site is provided in Appendix G.1.
5. PERMANENT CLOSURE AND RECLAMATION

5.1 Definition of Permanent Closure and Reclamation

Permanent closure is defined as “the final closure of the Mine with no foreseeable intent by the existing proponent to return to either active exploration or mining” (MVLWB et al., 2013). Permanent closure indicates that the proponent intends to have no further activity on the site aside from Post-Closure monitoring and potential contingency actions.

In December 2017, De Beers announced that the Mine would begin preparations for permanent closure.

For the purposes of planning for permanent closure and reclamation, two phases are defined, as follows:

- The **Closure phase** consists of the activities required to prepare the site for the final closure condition, including decommissioning, demolition, development of the closure water management system and active site revegetation. These activities are described in Sections 5.2 and 5.3. The Closure phase is considered to begin once a Water Licence for closure has been granted by the MVLWB. Once the closure activities are considered complete and active management of the site is no longer required, the site transitions to Post-Closure.

- The **Post-Closure phase** consists of on-going monitoring of the site to confirm that the required closure condition has been developed and to demonstrate achievement of the closure objectives. Contingency actions may be required during this phase but no active management of the site is planned. Post-Closure monitoring, maintenance and contingency planning are described in Sections 5.5 and 5.6.

5.2 Permanent Closure and Reclamation Requirements

This FCRP follows the Guidelines released by Aboriginal Affairs and Northern Development Canada (AANDC), now Indigenous and Northern Affairs Canada (INAC), and the Land and Water Boards of the Mackenzie Valley (the Boards) (MVLWB et al., 2013). The Guidelines outline specific requirements for closure objectives, options, selected closure activities, and criteria for presentation within the CRP. This section of the FCRP describes the details of the closure plan for the Mine, using the objectives-based approach first developed in the 2013 ICRP (version 3.2) for closure and reclamation planning. An overview of the adopted framework for closure planning is presented in Figure 5.1.

At the foundation of the objectives-based approach is the overarching closure goal for the site:

“To return the site and affected areas around the Mine to technically viable and, where practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities.”

This goal is supported by four closure principles identified by the Guidelines: physical stability, chemical stability, no long-term active care, and compatibility with land use in surrounding areas. The closure principles, which were defined in Section 2.2, are primary drivers in the development of closure objectives. Other major considerations in the selection of the closure objectives have included stakeholder feedback received throughout the impact assessment, regulatory process, and closure-specific engagement events.

De Beers Group
Additional considerations included findings of the EA, which comprised the assessment of Post-Closure conditions that were considered achievable.

**Figure 5.1  Objectives-based Approach to Closure Planning**

Proposed closure objectives were first submitted to the MVLWB in 2012 for stakeholder review. Subsequent community meetings, information sessions and workshops have provided valuable input into the refinement of the objectives and criteria (Appendix C). The development of the objectives and criteria are described in more detail in Section 5.2.3.

As shown in Figure 5.1, the prescribed approach includes development of options for potential closure activities that are expected to achieve each closure objective, and identification of a selected closure activity, once stakeholder input has been considered. De Beers first presented their proposed closure options and activities within the EAR document in 2002 (De Beers, 2002).

Section 4.5 discusses project alternatives assessed during the initial project design phase, the EA process, and operations; Section 5.3 discusses closure options on the basis of the current site footprint. On the basis of the selected closure option, the appropriate closure activities are discussed, including sub-tasks and associated engineering works required to support execution of the final closure phase.
Additional information required by the Guidelines (MVLWB et al., 2013), such as the pre-disturbance, existing, and final site conditions, predicted residual effects of the project, uncertainties for mine closure, planned Post-Closure monitoring programs, and contingency planning are also included in this section of the FCRP.

5.2.1 Project Component Description

An overview of the Mine site is presented in Figure 2.2. Detailed descriptions of each Mine Component are presented in Chapter 4, with accompanying figures/photographs compiled within Appendix F.

5.2.2 Pre-Disturbance, Existing and Final Site Conditions

Pre-disturbance, existing, and final site conditions for the major site components are summarized below in Table 5.1. Pre-disturbance conditions are discussed in detail within Section 3. Existing site conditions are demonstrated through various site photographs, images and maps presented in Section 4 and Appendix F. Following closure activities, all buildings and structures will have been removed from site with only the covered North Pile and related water management systems remaining. A figure depicting the expected Post-Closure Site Condition is presented as Figure 5.2.

Table 5.1 Summary of Pre-disturbance, Existing, and Final Mine Site Conditions

<table>
<thead>
<tr>
<th>Pre-Disturbance Condition</th>
<th>Existing Condition</th>
<th>Final Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Pile and Related Water Management Systems</td>
<td>Aerial photographs of the North Pile area existing conditions are provided in Appendix F. Three cells were planned for the North Pile facility. The Starter Cell and East Cell have been filled to near capacity, and construction of the West Cell had commenced shortly before the Mine entered Care and Maintenance. The North Pile received waste rock and processed kimberlite, as well as non-hazardous waste. Water management structures related to the North Pile are operational. These include water control structures, a dammed water management pond, water treatment plant and diffuser.</td>
<td>The North Pile will be covered with an engineered cover and the final surface sloped to promote runoff. The surface is expected to revegetate naturally. Permafrost aggradation into the materials deposited in the North Pile is expected to occur over time. At closure, the existing water management system will be re-configured to allow for passive gravity drainage, and may include installation of two constructed wetlands prior to release of water to Snap Lake. Additional information on activities that will be completed for the closure of the North Pile and related water management systems are discussed in Section 5.3.2</td>
</tr>
</tbody>
</table>
### Underground Mine

<table>
<thead>
<tr>
<th>Pre-Disturbance Condition</th>
<th>Existing Condition</th>
<th>Final Condition</th>
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</thead>
<tbody>
<tr>
<td>Descriptions of pre-disturbance environmental conditions are detailed in Section 3 of this FCRP. Physical setting and characteristics of the Underground Mine are described Section 4.6.2. No important or unique environmental conditions were identified in this area that would have a significant influence on closure planning.</td>
<td>A plan view figure depicting the current development of the Underground Mine is displayed in Figure 4.2. The underground mine was developed from 2008 until 2015, when the Mine entered C&amp;M. A minor amount of PK was deposited into the underground during PK deposition trials. In 2016, reclamation work was completed to permit the flooding of the underground mine. In 2017, all hazardous or salvageable materials were removed from the underground mine, to the Mine Inspector's satisfaction (GNWT, 2017), and permanent flooding of the Underground Mine concluded. Pumping systems currently facilitate the disposal of waste brine from the RO-WTP into the lowest practical level in the underground mine.</td>
<td>All surface features will be decommissioned and access to the underground will be sealed. Additional information on activities that will be completed for the closure of the underground mine are discussed in Section 5.3.3</td>
</tr>
</tbody>
</table>

### Site Infrastructure

<table>
<thead>
<tr>
<th>Pre-Disturbance Condition</th>
<th>Existing Condition</th>
<th>Final Condition</th>
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</thead>
<tbody>
<tr>
<td>Descriptions of pre-disturbance environmental conditions are detailed in Section 4 of this FCRP. Physical setting and characteristics of site Infrastructure are described in Section 4.6.3. No important or unique environmental conditions were identified in this area that would have a significant influence on closure planning.</td>
<td>Aerial photographs of existing conditions at infrastructure areas are provided in Appendix F.</td>
<td>At closure, the buildings will be fully decommissioned and removed. Non-hazardous materials will be disposed in the landfill, hazardous materials will be removed off-site for disposal, and hydrocarbon-contaminated soils remediated or removed from site. Building areas, site roads, airstrip and pads will be revegetated or prepared to facilitate natural colonization. Additional information on activities that will be completed for the closure of the site infrastructure are discussed in Section 5.3.4.</td>
</tr>
</tbody>
</table>

### 5.2.3 Closure Objectives and Criteria

This FCRP has incorporated specific feedback from stakeholders gathered as part of several engagement events completed regarding general mine closure discussions, as well as focused workshops dealing with specific components of the FCRP, notably closure objectives and criteria. A summary of engagement activities completed by De Beers to support ongoing closure planning is compiled in Appendix C.
Figure 5.2 Post-Closure Site Condition
As part of the ICRP, version 3.2 (Arktis, 2013), De Beers presented proposed closure objectives through the MVLWB review process. On November 22, 2012, the MVLWB provided a modified list of MVLWB-approved closure objectives (MVLWB, 2012) to De Beers, which were adopted for use in the ICRP. As outlined in the closure guidelines (MVLWB et al., 2013), four primary closure principles were considered during De Beers’ development of closure objectives for the major mine components. These closure principles include physical stability, chemical stability, compatibility with future land use, and no active care requirements. Each principle is defined in Section 2.2. The approved closure objectives are grouped within Site Wide (SW), North Pile (NP), Underground (UG) and Infrastructure (I) categories and presented in Table 5.2.

Proposed closure criteria and the method of measurement for each of the approved closure objectives were also first presented within version 3.2 of the ICRP (Arktis, 2013) in order to provide perspective regarding De Beers’ planned closure approach for each of the mine components, and to provide a starting point for engagement on the criteria. At the request of the MVLWB, De Beers presented updated closure criteria in the 2016 Annual Closure and Reclamation Plan Progress Report (De Beers, 2017h). The criteria were subject to a stakeholder written review process as part of the annual report submission. These closure criteria were also the focus of discussions at the May and December 2017 (MVLWB, 2017b), and November 2018 closure workshops (MVLWB, 2018). The revised closure criteria, as presented in this FCRP, have been updated to reflect feedback received in 2017 and 2018 and have also been informed by ongoing closure planning. A summary table outlining how De Beers’ commitments from the ICRP version 3.2 and stakeholder recommendations from the workshop have been carried forward into the current closure criteria is presented in Appendix C.

Table 5.2 summarizes the closure objectives, closure criteria, primary reclamation activities, and Post-Closure inspections and monitoring planned to evaluate achievement of the criteria. Detailed descriptions of these topics are presented throughout Section 5.

Each set of closure objectives, criteria and performance monitoring programs provide clear, measurable targets for permanent closure and reclamation at the Mine as required by the Guidelines. Section 9 provides additional detail on the means of assessing and demonstrating completion of closure objectives.

### 5.3 Closure Activities

As described in Section 5.2, through the closure planning process closure objectives are used to identify closure options, from which the preferred closure activity is selected. This section details the options considered for each component, rationalizes the selection of the preferred closure activity, and provides the associated engineering and construction work required to implement the preferred activity.

Consideration of closure options and identification of preferred closure activities initially began during the project design phase and the EAR development process (De Beers, 2002). At that time, major project options were evaluated (e.g., number and location of PK piles), with consideration of the associated potential environmental impacts and closure requirements. A summary of these completed options analyses, including the selected activity and rationale, is presented in Section 4.5. Specific closure activities were also developed as part of the EAR, in conjunction with the selection of the project design, to support the assessment of the potential Post-Closure impacts from the Mine.
<table>
<thead>
<tr>
<th>Site Wide</th>
<th>SW1 - Dust levels safe for people, vegetation, aquatic life and wildlife.</th>
<th>SW2 - Drainage pathways for surface runoff are physically stable.</th>
<th>SW3 - Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife.</th>
<th>SW4 - Mine areas are physically stable and safe for use by people and wildlife.</th>
<th>SW5 - Landscape features (shape and vegetation) match aesthetics of the surrounding natural area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure Objective</td>
<td>Closure Criteria</td>
<td>Primary Reclamation Activities</td>
<td>Post-Closure Inspections and/or Monitoring</td>
<td></td>
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</tr>
<tr>
<td>1. Physical Stability</td>
<td>Not applicable as this is a chemical objective.</td>
<td>Engineering design and construction of a cover placed over the North Pile. Cessation of mining and construction activities (e.g., diesel combustion, surface vehicle traffic, blasting, material crushing and handling, etc.) play a large role in diminished air emissions.</td>
<td>Air quality monitoring for suspended particulates and dustfall will be conducted during closure. Geotechnical monitoring of the drainage pathways will occur. Final grading where required to promote positive drainage. Drainage pathways (e.g., spillways at the North Pile) will be established as per design and QA/QC. QA/QC protocol completed by a professional engineer.</td>
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<tr>
<td>2. Chemical Stability</td>
<td>a) Ambient air quality shall not exceed the Northwest Territories Ambient Air Quality Standards (NWTTAQS) as demonstrated by monitoring during closure. b) Dustfall shall not exceed the Alberta Ambient Air Quality Guidelines (AAAGQ) as demonstrated by monitoring during closure.</td>
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<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetics objectives are met through chemical stability criteria as described in SW1-2.</td>
<td>Geotechnical inspections (visual) of the drainage pathways will occur. Final grading where required to promote positive drainage. Drainage pathways (e.g., spillways at the North Pile) will be established as per design and QA/QC. QA/QC protocol completed by a professional engineer.</td>
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<td>Geotechnical monitoring of temperature monitoring within the North Pile area, visual monitoring of engineered covers for signs of deformation and/or degradation. Water quality monitoring (runoff and seepage at locations of concern across the site).</td>
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<td>Closure Objective</td>
<td>Closure Criteria</td>
<td>Primary Reclamation Activities</td>
<td>Post-Closure Inspections and/or Monitoring</td>
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</tr>
<tr>
<td>1. Physical Stability</td>
<td>Not applicable as this is a chemical objective. Relevant physical stability criteria are provided in NP1 and SW2.</td>
<td>Final grading where required to promote positive drainage. Drainage pathways (e.g., spillways at the North Pile) will be established as per design and QA/QC. QA/QC protocol completed by a professional engineer.</td>
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<tr>
<td>2. Chemical Stability</td>
<td>Meet Effluent Quality Criteria (EQCs) in surface discharge to achieve in-lake site specific water quality objectives (SWWQOs) as described in the approved MVLWB Water Licence and demonstrated by Post-Closure monitoring for a minimum period of 5 years after construction of the passive water treatment system.</td>
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<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetics objectives are met through chemical stability criteria as described in SW2-1. Where appropriate, aesthetic considerations have been included in designs.</td>
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<td>Closure Objective</td>
<td>Closure Criteria</td>
<td>Primary Reclamation Activities</td>
<td>Post-Closure Inspections and/or Monitoring</td>
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<tr>
<td>1. Physical Stability</td>
<td>Not applicable as this is a physical objective.</td>
<td>Final grading where required to promote positive drainage. Drainage pathways (e.g., spillways at the North Pile) will be established as per design and QA/QC. QA/QC protocol completed by a professional engineer.</td>
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<td>2. Chemical Stability</td>
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<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetics objectives are met through chemical stability requirements under SW3-2, whereby EA 1314-D2 Measure 1 parts a through c (MVIRB, 2014) water quality objectives will be satisfied.</td>
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<tr>
<td>Closure Objective</td>
<td>Closure Criteria</td>
<td>Primary Reclamation Activities</td>
<td>Post-Closure Inspections and/or Monitoring</td>
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<tr>
<td>1. Physical Stability</td>
<td>Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>Final grading will promote positive drainage towards pre-disturbance drainage pathways where possible. Drainage pathways will be established for long-term stability to avoid issues with erosion.</td>
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<tr>
<td>2. Chemical Stability</td>
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<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetics objectives are met through chemical stability criteria as described in SW4-1.</td>
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<tr>
<td>Closure Objective</td>
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<td>Primary Reclamation Activities</td>
<td>Post-Closure Inspections and/or Monitoring</td>
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<tr>
<td>1. Physical Stability</td>
<td>There will be no visible buildings, equipment or non-local materials remaining on site. Construction of physically stable drainage pathways is addressed in SW2.</td>
<td>Final grading will reflect surrounding topography and re-establish natural drainage pathways where possible. Engineering design of North Pile will not exceed elevation of surrounding terrain. Revegetation efforts as detailed in Closure Objective SW7.</td>
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<tr>
<td>2. Chemical Stability</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>a) Final grading will reflect surrounding topography (i.e., steep edges of pits and trenches flattened or backfilled) with slopes of 3:1 where possible through engineering design. Natural drainage pathways will be re-established, where possible. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer. b) Revegetation targets for the key priority areas are addressed under SW7.</td>
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<td><strong>SW6 - Safe passage and use for Caribou and other wildlife.</strong></td>
<td>1. <strong>Physical Stability</strong>&lt;br&gt;Where possible through engineering design, a 3:1 slope in mine-impacted areas will be achieved to facilitate caribou passage. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.&lt;br&gt;&lt;br&gt;2. <strong>Chemical Stability</strong>&lt;br&gt;Not applicable as this is a physical objective; chemical stability is addressed under SW1 and SW3.&lt;br&gt;&lt;br&gt;3. <strong>Future Use and Aesthetics</strong>&lt;br&gt;Future use and aesthetic objectives are met through physical criteria as described in SW6.1.</td>
<td>Removal of all buildings, equipment, and surface hazards. Engineered earthen structures remaining at the site (i.e., North Pile) will be physically stable. See NP closure objectives below for details specific to stability of mine waste areas. Mitigation of environmental risk to wildlife from soil, sediment or water will be completed as required based on the applicable closure criteria for environmental media, as detailed in Closure Objectives SW2 and 13. Reclamation of fresh water intake facilities, the effluent diffuser and other aquatic habitats per the Fish Habitat Compensation Plan developed in consultation with DFO.</td>
<td>Final landscape inspected by a qualified professional and representatives of SLEMA. Submission of as-built conditions in a summary report completed by a qualified person. Water quality monitoring (runoff and seepage at locations of concern across the site), Wildlife monitoring at the Mine area. Geotechnical inspections (visual) of the site will occur Post-Closure in concert with the site geotechnical inspection and monitoring program.</td>
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<td><strong>SW7 - Revegetation targeted to priority areas.</strong></td>
<td>1. <strong>Physical Stability</strong>&lt;br&gt;Not applicable as this is a future use and aesthetics objective as described in SW7. Physical stability is addressed through site wide and infrastructure objectives (SW2, SW4, NP2, 12).&lt;br&gt;&lt;br&gt;2. <strong>Chemical Stability</strong>&lt;br&gt;Not applicable as this is a future use and aesthetics objective as described in SW7. Chemical stability is addressed through site wide and infrastructure objectives (SW9, 11, 12, 13).&lt;br&gt;&lt;br&gt;3. <strong>Future Use and Aesthetics</strong>&lt;br&gt;a) Revegetation activities, including scarification, soil preparation, and seeding, shall be successfully completed at priority areas to promote natural recovery. Priority areas are defined as the mine building and main laydown area.&lt;br&gt;b) A 5% mean plant coverage on upland areas is targeted within 5 years of seeding as measured by Post-Closure monitoring, resulting in a mean plant coverage of 29.5% over the LSA.</td>
<td>Revegetation efforts will include some combination of the following activities across the various mine areas:&lt;br&gt;Grading surfaces to promote drainage and limit pooling, surface material loosening (scarification); Placement of salvaged overburden as a growth amendment to priority locations; Application of native species; and Additional activities as identified through revegetation research.</td>
<td>Final landscape inspected by a qualified professional and representatives of SLEMA. Submission of as-built conditions in a summary report completed by a qualified person. Vegetation monitoring will be completed to evaluate the establishment of vegetation at reclaimed surfaces across the site and provide a documented case study for future projects.</td>
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**North Pile**

<p>| <strong>NP1 - Prevent PK from entering the surrounding terrestrial and aquatic environment.</strong> | 1. <strong>Physical Stability</strong>&lt;br&gt;a) Closure design of engineered structures (including a &lt;0.3 m cover and water control structures) is prepared by a professional engineer and approved by the Water Board as necessary.&lt;br&gt;b) Engineered closure works are constructed according to design and as-built reports are prepared by the engineer.&lt;br&gt;c) Facility (including perimeter embankments, water control structures and instrumentation) is routinely monitored according to design and under the direction of a professional engineer.&lt;br&gt;d) Facility is periodically inspected and cumulative monitoring data reviewed against design by a professional engineer.&lt;br&gt;e) Inspection reports are prepared by the engineer including recommended maintenance work and recommended adjustments to the monitoring program.&lt;br&gt;f) Recommended maintenance work is implemented by the owner or otherwise addressed in a timely manner.&lt;br&gt;g) As-built reports, monitoring results, inspection reports and maintenance descriptions are provided to the Water Board.&lt;br&gt;h) Post-Closure monitoring and inspection program proceeds for a minimum of three years and then progressively decreases in scope and frequency based on demonstrated stability, in coordination with the site-wide Post-Closure monitoring program, and in accordance with recommendations of the engineer. | Engineering design and construction of the North Pile and cover by a professional engineer. Deposition of PK within the North Pile Facility, which will include a material cover at closure. | Geotechnical inspections (visual) of the site will occur Post-Closure in concert with the site geotechnical inspection and monitoring program. Thermal monitoring will be completed using thermistor cables installed in the North Pile. Water quality monitoring of seepage will occur at the North Pile area as outlined in the SNP. |</p>
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<th>Closure Objective</th>
<th>Closure Criteria</th>
<th>Primary Reclamation Activities</th>
<th>Post-Closure Inspections and/or Monitoring</th>
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<tr>
<td>NP2 - Physically stable</td>
<td>Physical Stability</td>
<td>Acceptable results, as identified in NP1, of visual monitoring for deformation and degradation for a minimum of three years. Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>Final landscape inspected and submission of as-built conditions in a summary report completed by a professional engineer. Closure geotechnical monitoring. Area inspected and as-built drawing is deemed acceptable and signed-off by a professional engineer. Geotechnical inspections (visual) of the site will occur Post-Closure in concert with the site geotechnical inspection and monitoring program. Thermal monitoring will be completed using thermistors that will be installed in the North Pile. Permafrost establishment is not required to achieve stable slopes, but may enhance it.</td>
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<td>PM1 - Focus on safety</td>
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<td>Accessibility</td>
<td>Future Use and Aesthetics</td>
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<td>IS10 - Flooded mine will have no impacts to aquatic habitat and community in source lakes</td>
<td>Physical Stability</td>
<td>Not applicable as physical stability of the underground mine is addressed in UG3.</td>
<td>In accordance with the MVLWB approved Extended Care and Maintenance Plan (De Beers, 2018d), the underground mine was flooded between February and May 2017. Any waters that escape from the underground will be treated as surface runoff and covered by actions described under SW3. Post-Closure aquatic effects monitoring of Snap Lake.</td>
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<td>Chemical Stability</td>
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<tr>
<td>IS20 - Open pit mine will have no impacts to aquatic habitat and community in source lakes</td>
<td>Future Use and Aesthetics</td>
<td>Future use and aesthetics will be met through physical criteria as described in NP2.1. Final grading will reflect surrounding topography.</td>
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<tr>
<td>IS30 - Underground mine workings will be physically stable</td>
<td>Physical Stability</td>
<td>Prior to flooding, the Mine was physically stable in accordance with the WSCC WNFT’s Mines Act requirements. All Mine openings to surface, and permanent seals, will be designed and inspected in accordance with WNFT Mines Act and associated regulations and will be constructed and inspected for a minimum of three years Post-Closure by a professional engineer.</td>
<td>Engineering design of concrete caps for mine portals and raises by a professional engineer. Geotechnical inspections (visual) of the site will occur Post-Closure in concert with the site geotechnical inspection and monitoring program.</td>
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<td>IS40 - Underground mine will not contribute to the contamination of ground or surface water</td>
<td>Future Use and Aesthetics</td>
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<td>IS50 - Underground mine will not contaminate the aquatic environment</td>
<td>Chemical Stability</td>
<td>The removal of all potential contaminant sources was done prior to flooding in consultation with the GNWT Inspector. This objective will be demonstrated through Post-Closure monitoring as described in SW3-2.</td>
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<td>IS60 - Underground mine will not contaminate the aquatic environment</td>
<td>Future Use and Aesthetics</td>
<td>Not applicable as physical stability of the underground mine is addressed in UG2</td>
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<td>IS70 - Underground mine will not contaminate the aquatic environment</td>
<td>Future Use and Aesthetics</td>
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<tr>
<td>IS80 - Underground mine will not contaminate the aquatic environment</td>
<td>Future Use and Aesthetics</td>
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**Infrastructure**

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<th>Primary Reclamation Activities</th>
<th>Post-Closure Inspections and/or Monitoring</th>
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<tr>
<td>IS1 - Prevent remaining infrastructure from contaminating land or water</td>
<td>Physical Stability</td>
<td>Physical stability is addressed in SW4 and I2.</td>
<td>All potentially hazardous materials and equipment will be removed from site. Any waters released from the underground prior to capping of the portals will be treated as surface runoff and covered by actions described under SW3. Water quality monitoring (at locations of concern across the site). Post-Closure aquatic effects monitoring of Snap Lake.</td>
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<td>Chemical Stability</td>
<td>Following the completion of a Hazardous Substances Assessment all potentially hazardous materials will be removed off-site to an approved disposal facility or treated on-site as per the approved Waste Management Plan. Any residual soil contamination will be addressed as described in I3.</td>
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<td>Future Use and Aesthetics</td>
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| IS2 - On-site disposal areas are safe for people, wildlife, and vegetation | Physical Stability | a) Any on-site disposal area (i.e., North Pile Landfills) will be designed and constructed by a professional engineer. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer. | Isolation of contaminated soils and non-hazardous waste within disposal areas designed and inspected by a professional engineer. The WMP and North Pile sumps will be covered to stabilize accumulated sediments. Final landscape inspected and submission of as-built conditions in a summary report completed by a professional engineer. Post-Closure geotechnical monitoring at appropriate locations. Area inspected and as-built drawing is deemed acceptable and signed-off by a professional engineer. Geotechnical inspections (visual) of the site will occur Post-Closure in concert with the site geotechnical inspection and monitoring program. |
| | Chemical Stability | Chemical stability will be achieved by removing/treating all hazardous waste as described in objectives I1 and I3. | |
| | Future Use and Aesthetics | Future use and aesthetic objectives will be met through physical criteria as described in I2-1. | |
## Closure Objective

### I3 - Contaminated soils and waste disposal areas that cannot contaminate land and water.

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<th>Closure Objective</th>
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<th>Primary Reclamation Activities</th>
<th>Post-Closure Inspections and/or Monitoring</th>
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<tr>
<td>1. Physical Stability</td>
<td>Physical stability is addressed through SW4 and I2.</td>
<td>Post-Closure Environmental Site Assessment and Remedial Action Plan completed by a professional engineer or geoscientist, in accordance with GNWT guidelines (GNWT, 2003).</td>
<td>Final landscape inspected by a qualified professional representative of affected Indigenous Parties to confirm completion of remedial activities. Water and soil quality monitoring may be required. This will be determined during development of the Remedial Action Plan.</td>
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<td>2. Chemical Stability</td>
<td>Contaminated soil areas at the Mine are remediated in accordance with the GNWT Environmental Guideline for Contaminated Site Remediation and to the satisfaction of a professional engineer or geoscientist.</td>
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<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetics are met through I3-2 and I2.</td>
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The approval of the proposed closure objectives in 2012 provided specific targets for the closure activities planned at each mine component and site wide targets for broader closure topics. Closure options to address objectives were first presented in ICRP version 3.1 in 2011 and discussed within the 2013 MVLWB workshop, the ICRP version 3.2 review, and the 2018 and 2019 MVLWB workshops. Throughout this multi-year closure planning process, uncertainties have been identified and addressed through reclamation research programs and engineering studies, ultimately progressing to the detailed engineering studies developed for the FCRP. A summary of research programs identified and completed since 2013 is provided in Appendix E.

Closure options and the resulting closure activities planned are described in the following sub-sections for the major mine components.

5.3.1 Site Wide

Section 5.2.3 outlines seven (7) closure objectives that apply site wide. Table 5.3 links these objectives with Project components, and Figure 5.3 shows how the associated closure activities and monitoring programs integrate together. The site wide closure objectives are appropriately evaluated at the scale of the entire site as opposed to the scale of an individual site component; however the detailed closure activities that will lead to their success are embedded within the descriptions for the North Pile, Underground Mine, and Infrastructure. Figure 5.2 provides a map of the site in the Post-Closure Condition when all of these objectives would be achieved.

5.3.1.1 Closure Alternatives

Table 5.4 summarizes the closure alternatives considered, and selected (bold font) to support achieving the associated site wide closure objectives. Further details regarding the primary alternatives is provided in sections specific to the North Pile and Related Water Management Systems (Section 5.3.2.1); Underground Mine (Section 5.3.3.1); and Infrastructure (Section 5.3.4.1).

5.3.1.2 Engineering Work Associated with Selected Closure Activities

The following sections describe work associated with site-wide closure activities. Additional detail related to aspects of this work will also be addressed in sections specific to the North Pile and Related Water Management Systems (Section 5.3.2.2); Underground Mine (Section 5.3.3.2); and Infrastructure (Section 5.3.4.2).

Environmental Hazards Assessment

Mining activities have resulted in the potential for select areas of the site to have elevated levels of contaminants. Contamination can be caused by activities such as, minor spills, equipment malfunctions, waste management, and materials storage. Any contamination will need to be managed to acceptable levels as part of final mine closure.
### Figure 5.3  Integrated Summary of Closure Activities and Programs

#### Site Wide Closure

**Objectives:**
- SW1 – Dust levels safe for people, vegetation, aquatic life and wildlife.
- SW2 – Drainage pathways for surface runoff are physically stable.
- SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife.
- SW4 – Mine areas are physically stable and safe for use by people and wildlife.
- SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area.
- SW6 – Safe passage and use for Caribou and other wildlife.
- SW7 – Revegetation targeted to priority areas.

**Key Activities:**
- Environmental Hazards Assessment
- Landform Design
- Revegetation

**Programs:**
- Geotechnical Inspections
- Air Quality and Emissions Monitoring
- Meteorological Monitoring
- Vegetation Monitoring
- Wildlife Effects Monitoring Program

#### North Pile Closure

**Objectives:**
- NP1 – Prevent PK from entering the surrounding terrestrial and aquatic environment.
- NP2 – Physically stable PK containment area to limit risk of failure that would affect safety of people or wildlife.

**Key Activities:**
- Landfill
- Graveling and Drainage
- Rock Cover
- Water Management Structures
- Passive Water Treatment

**Programs:**
- Geotechnical Inspections
- Hydrological Monitoring
- Surveillance Network Program
- Aquatic Effects Monitoring Program

#### Infrastructure Closure

**Objectives:**
- I1 – Prevent remaining infrastructure from contaminating land or water.
- I2 – On-site disposal areas are safe for people, wildlife, and vegetation.
- I3 – Contaminated soils and waste disposal areas that cannot contaminate land and water.

**Key Activities:**
- Winter Road Logistics
- Building and Equipment Demolition
- Removal of Crossing Structures
- Waste Management

**Programs:**
- As-built documentation

#### Underground Mine Closure

**Objectives:**
- UG1 – Flooding of the underground mine will have no impacts to aquatic habitat and community in source lakes.
- UG2 – Underground mine should not contribute to the contamination of ground or surface water.
- UG3 – Underground mine workings are physically stable.

**Key Activities:**
- Flooded Mine Workings [completed]
- Seal Mine Portals
- Seal Ventilation Rises

**Programs:**
- As-built documentation
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<tr>
<th>Matrix of Closure Objectives and Project Components</th>
<th>Site Wide</th>
<th>East Cell</th>
<th>Starter Cell</th>
<th>North Pile</th>
<th>Underground Mine</th>
<th>North Rim</th>
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Table 5.3

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<th>Site Wide</th>
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## Mine Infrastructure

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### Selected Closure Activities

- 1. Leave swales in place
- 2. Regrade and contour
- 3. Contaminated soil remediation as required
- 4. Safe passage pathways for terrestrial and aquatic life
- 5. Dismantle and dispose
- 6. Contaminated soil remediation
- 7. Contaminated soil remediation

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## De Beers Group

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**SNAP LAKE MINE**

**Final Closure and Reclamation Plan**

March 2019
<table>
<thead>
<tr>
<th>Closure Objectives</th>
<th>Alternative Options Considered</th>
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| SW1 – Dust levels safe for people, vegetation, aquatic life and wildlife.          | - Construct an engineered cover over deposited waste materials in the North Pile.  
- Leave “as is”, allow natural recovery of vegetation and geomorphological reshaping processes.                                                                 |
| SW2 – Drainage pathways for surface runoff are physically stable.                   | - Reshape surface materials to establish physically stable drainage pathways.  
- Leave “as is”, allow natural recovery of vegetation and geomorphological reshaping processes.                                                                 |
| SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife. | - Disposal of all PK, PAG rock and non-hazardous waste materials in the North Pile facility, and capped with an engineered cover at closure.  
- Removal of all potentially hazardous materials and equipment.  
- Drainage pathways established for long-term stability.  
- Development of passive water treatment system for use if required to meet EQC.  
- Retain active water treatment system.  
- No additional options were considered.                                                                 |
| SW4 – Mine areas are physically stable and safe for use by people and wildlife.     | - Final grading to promote positive drainage towards pre-disturbance drainage pathways where possible.  
- Drainage pathways established for long-term stability.  
- Engineering design of earthen structures remaining at the site (i.e., North Pile) to be physically stable.  
- Leave “as is”.                                                                 |
| SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area. | - Removal of all buildings, equipment, and surface hazards.  
- Leave select buildings for future use by indigenous communities.  
- Final grading to reflect surrounding topography and re-establish natural drainage pathways where possible.  
- Leave airstrip as-is.  
- Engineering design of North Pile will not exceed elevation of surrounding terrain, with an intermediate footprint.  
- Engineering design of North Pile to exceed elevation of surrounding terrain but with a smaller footprint.  
- Engineering design of North Pile to remain lower than elevation of surrounding terrain but with a larger footprint.  
- Revegetation efforts at priority areas to optimize the use of overburden materials that were stockpiled for reclamation use.  
- Quarries developed primarily within North Pile footprint.  
- Quarries developed external to North Pile.                                                                                                                                 |

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**Table 5.4  Closure Alternatives Related to Site Wide Closure Objectives**
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<th>Closure Objectives</th>
<th>Alternative Options Considered</th>
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| SW6 – Safe passage and use for Caribou and other wildlife. | ● Removal of all buildings, equipment, and surface hazards.  
  ● Engineered earthen structures remaining at the site (i.e., North Pile) to be physically stable.  
  ● Mitigation of environmental risk to wildlife from soil, sediment or water based on the applicable closure criteria for environmental media.  
  ● Reclamation of fresh water intake facilities and the effluent diffuser.  
  ● No additional options were considered. |
| SW7 – Revegetation targeted to priority areas.          | ● Revegetation efforts will include some combination of the following approaches:  
  ○ Grading surfaces and surface material loosening (scarification);  
  ○ Placement of salvaged overburden to priority locations;  
  ○ Application of native species.  
  ● No additional options were considered. |

A Phase II Environmental Site Assessment (ESA) will be completed at the Mine in accordance with the guidelines and principles established by the Canadian Standards Association in the document CSA Z-769/00, and overseen by a qualified professional. Sampling and analysis will be conducted to:

- Determine the presence or absence of contaminated soil;
- Determine the presence or absence of contaminated surface water;
- Delineate the extent of contamination (if present);
- Provide volume estimates of contaminated soil/water within the areas investigated; and
- Provide remediation recommendations in the form of a Remedial Action Plan (RAP). Special consideration will be given to the Risk Assessment option to minimize active remedial requirements.

Sampling of surface soil and water will be conducted across the entire Mine site to identify Areas of Potential Environmental Concern (APECs), particularly targeting those areas where the primary activity could lead to potential contamination or where previous spills are known to have occurred, including:

- Emulsion plant area and ammonium nitrate storage facility;
- Inland Lake 6 watershed catchment;
- Temporary hazardous material storage area;
- Laydown 1;
- Former construction camp; and
- Fuel storage areas.

It is noted that additional APECs may be identified through this process to ensure the entire site is fully assessed.
Analytical results will be compared against applicable guidelines that will ensure the remediated site is safe for use by people and wildlife. Appendix I provides an overview of the applicable guidelines related to various media and exposure paths across the site.

A Phase II report will be completed that addresses the requirements and objectives of the study, the presence or absence of contaminants and their location(s), and an RAP. Recommendations regarding handling, storage and disposal of identified materials will be consistent with the Waste Management Plan (DeBeers, 2019b).

The recommendations of the RAP will be carried out under the guidance of a qualified professional to support achievement of closure objectives SW3, as well as NP1 and I3.

**Landform Design**

The final landform design of the site is detailed in Appendix G.3.

The overall topography of the site can be described as gently sloping with occasional knolls. The elevation of the mine site varies from approximately 445 m at Snap Lake to approximately 470 m on a knoll located southwest of the WMP. In general, natural drainage for the plant site area flows from a local topographic high, east of the mine portal, and collects in the WMP to the west of the plant site area. Current grading within the natural catchment area of the Mine site is designed to collect and promote positive drainage towards the WMP.

As part of closure activities, the North Pile will be regraded to achieve passive drainage, and an engineered cover installed to ensure long-term physical and chemical stability. This is described in Section 5.3.2.2.

In addition, the following have been identified as having the potential to require greater efforts for grading and contouring compared to the remainder of the disturbed areas:

- Mine Surface Facilities and Former Camp Area;
- Culvert/conduit locations; and
- Quarry.

Reclamation activities for these areas will include:

- Removal of existing culverts, pipes and conduits.
  - Culverts/conduits will be removed and the materials disposed as per the approved waste disposal method.
  - Culverts/conduits located along major right-of-way – the final reclamation condition of the roadway includes a grade that should not be less than 3H:1V with a base width that permits vehicle traffic. A typical drawing of the condition after reclamation is presented in Appendix G.3.
  - Culverts located where water conveyance is necessary – a typical drawing of the condition after reclamation is presented in Appendix G.3, and generally includes a 3H:1V side slope and minimum 2 m base width. The side slopes and base are to be covered with a non-erodible (minimum 150 mm down) material of a 0.3 m thickness.
**Remaining conduits** – these are conduits that are not located along a major right-of-way or where water conveyance is not necessary. These conduits may be left in place so as to reduce further ground disturbance. If removed the excavation would be backfilled with the locally available material and compacted to mitigate settlement and left in a stable condition. Appendix G.3 depicts the typical final reclamation condition.

- Contouring slopes and disturbed areas
  - Slopes will be re-contoured to achieve the closure objectives and/or where necessary contoured to minimum 3H:1V. These slopes will be identified during a site inspection. Any contouring of slopes will utilize locally available material and be overseen by a qualified professional.
  - Disturbed surfaces will be contoured to encourage water drainage and limit water pooling. Where possible, water drainage will be directed to existing drainage paths, and will be graded to a slope that will not cause erosion.
  - A final surface grading as-built for the site will be developed and overseen by a professional engineer.

Combined, these activities will support achievement of the following site wide closure objectives: SW1 (dust management); SW2 (physically stable drainage); SW4 (safe for use by people and wildlife); and SW5 (match aesthetics of surrounding area). They will also prepare the site for revegetation.

**Revegetation**

The revegetation program will allow for a natural progression of native vegetation species to develop on the reclaimed landscape over time. This will be supplemented by active seeding or planting of native vegetation at selected sites in order to prevent erosion or dust generation and to help speed the process of natural succession. The Snap Lake Revegetation Plan (Appendix J.1) details the methodologies applied to revegetate the upland (dry), disturbed areas of the Mine within the LSA, which represent the majority of the disturbed areas to be reclaimed. The outcomes of revegetation research (Appendix J.2) completed to date for the Mine, as well as at other northern and applicable mine sites have been considered in the development of the Snap Lake Revegetation Plan.

As indicated in Figure 5.4, both active and passive revegetation methods are planned. The areas on the map shown in pink have been identified as a relatively contiguous area where the available stockpiled overburden material would be best utilized to contribute to revegetation efforts. Active revegetation areas (pink and brown on the map) will be scarified, followed by the addition of seed and/or fertilizer. Passive revegetation (yellow areas on the map) is planned for the North Pile, which will receive an engineered cover (see Section 5.3.2), as well as for slopes along the edges of roads, pads and laydowns where equipment access is not safe or is difficult.

Revegetation success will be tracked through the Revegetation Reclamation Design monitoring plan (Section 6.0 of Appendix J.1), which includes a feedback mechanism for adaptive management. The outcomes of this monitoring will directly support achievement of the site wide closure objective SW7 (revegetation), and indirectly support others.
Figure 5.4  Site-Wide Revegetation Methods
5.3.2 North Pile and Related Water Management Systems

The focus of closure water management planning is on the North Pile and related water management system, which will represent a permanent feature on the Post-Closure landscape. As such, the engineering design and associated technical analyses that are described in this section have focused on the following key objectives:

- Achievement of physical and chemical stability closure objectives and criteria;
- Passive conveyance of North Pile drainage to Snap Lake;
- Identification of appropriate end of pipe (EQC) and receiving environment (AEMP benchmark) criteria during Post-Closure; and
- Minimum requirements for long-term maintenance to allow a path to relinquishment.

It is important to note that without the need to pump water from within the underground mine, the volume of water requiring management during Post-Closure is significantly reduced from (approximately 1% of) the amount of water managed during operations. The proposed base case water management system, described in Section 5.3.2, takes a conservative approach that includes a passive treatment system requiring expansion of two existing ponds for water storage and equalization, and installation of two constructed wetlands to treat nitrate concentrations prior to release to Snap Lake (Appendix L.2). There is confidence that, over time, nitrate loadings from the North Pile will reduce as a result of reclamation work, permafrost development, and mass load depletion, such that continued water treatment may no longer be required, but there is uncertainty regarding the timeframe within which these reductions will be realized. As described in the following sections, on-site monitoring is on-going and will be used to better define this uncertainty and to inform specific mitigations required for nitrate management.

5.3.2.1 Closure Alternatives

North Pile Closure Cover

As described in Chapter 4, and in the initial mine plan, the closure design for the North Pile has been influenced by two variables:

- quantity of processed kimberlite stored underground; and
- pile height and footprint.

These are well documented in the record (e.g., see ICRP version 3.2). With the decision to move the mine to full closure, the focus has shifted from optimizing and configuring the size and location of the North Pile, to a detailed evaluation of the design of a closure cover for the pile in its current form. Key design objectives of the North Pile closure cover include:

- resist wind and water erosion;
- physically isolate waste materials from the surrounding environment;
- provide safe access and egress for wildlife;
- promote surface runoff; and
- reduce infiltration of water into the North Pile.
As part of pre-feasibility design, Golder (Appendix H.3 2018f) evaluated closure cover options and re-validated that the initial design of an engineered cover, as described in the EAR (De Beers, 2002), remains the most appropriate approach for the site to achieve these objectives. The details of this design have since been advanced to feasibility level (Golder, 2018e, Appendix H.2) and detailed design (Golder, 2019a, Appendix H.1).

Three engineered cover design profiles have been developed for the North Pile, with different cover configurations proposed for the deposited PK, landfill waste, and rib berm areas. The different materials to be covered have slightly different technical requirements, resulting in the different cover configurations:

- **Deposited PK** – total cover thickness of 600 mm:
  - 300 mm of erosion protection cover material, equivalent to twice the nominal size of 150 mm.
  - Nominal 300 mm of transition material.
    - The thickness of the transition layer will be optimized based on the results of field trials conducted in 2018/2019 and construction observations. The constructability of a thinner layer (minimum 150 mm) that still meets the design intent will be evaluated during construction of the closure cover by the geotechnical engineer.

- **Landfill waste** – total cover thickness of 2 m to meet regulatory commitment:
  - 300 mm of erosion protection cover material, equivalent to twice the nominal size of 150 mm
  - 1.4 m of non-acid generating material, which may be a combination of erosion protection cover and transition materials, depending on availability.
  - Nominal 300 mm of transition material (assuming landfilled material will be covered with fine PK as part of deposition)
    - The constructability of a thinner layer (minimum 150 mm) that still meets the design intent will be evaluated during construction of the closure cover by the geotechnical engineer.

- **Embankment / rib berm** – total cover thickness of 300 mm
  - 300 mm of erosion protection cover.
  - Transition material is not required on rib berms.

These new cover profiles have been derived through the normal optimization process of feasibility study, including updated physical and geochemical stability analysis, and are documented in Golder, 2019a (Appendix H.1).

**Water Conveyance Systems**

A key design objective for closure of the North Pile is to passively collect and convey seepage and surface water runoff away from the North Pile, to manage water for extreme events and to safely direct it to the receiving environment in a manner that achieves closure objectives and criteria. Water management design options have been evaluated through multiple, integrated analyses:

- Grading plan (Golder, 2019a, Appendix H.1);
The three-dimensional civil design software AutoCAD Civil 3D 2017 (Autodesk 2017) was used to evaluate alternative configurations and to develop the design and drawings for the North Pile closure cover.

- During early design iterations, options were explored to direct all surface water flow east toward the Sump 3 and the WMP. However, in order to maintain the design gradient and accommodate landfill waste material in the East Cell, the closure cover configuration would require an impractical embankment raise of approximately 10 m along the west portion of Cell 1.

- Closure of the North Pile in accordance with the grading plan will provide a final configuration that resists erosion and conveys a majority of the surface water runoff to the east (to Sump 3), with a small portion of runoff conveyed to the west (to Sump 5).

**Stability analysis (Golder, 2019a, Appendix H.1);**

- Development of the final geometry of the closed North Pile will require excavations for the placement of landfill material. Slope stability analysis was completed to assess the permissible slopes for excavation of PK, and to confirm the long-term stability of the embankments. Based on the results of the assessment, feasible embankment raise and excavation geometries have been developed, which meet conservatively selected factor of safety (FoS) criteria, including where applicable the CDA (2013) standards for the closure passive care phase.

- A geochemical stability analysis was performed to assess the acid rock drainage potential of PK, waste rock, and rockfill materials (Appendix K). Data indicate that seepage through the North Pile would not produce significant acidity due to the excess internal buffering capacity of the waste rock and PK.

**Surface water management analysis (Appendices L.2 and L.3);**

- Based on the grading plan, a surface water management analysis was performed to determine the length, width, depth, side slope, and revetment for the swales and channel outlets included in the closure cover design (Golder, 2019a, Appendix H.1). Two swales will be constructed on the East Cell closure cover surface to convey surface water toward the Cell 1 (west) and Cell 5 (east) channel outlets. One swale will be constructed on the Starter Cell closure cover surface to convey surface water toward the Cell 5 (east) channel outlet.

- The ability for passive discharge of North Pile perimeter drainage was evaluated (Appendix L.2). To achieve gravity-fed flow, as opposed to long-term active pumping, two discharge locations in Snap Lake would be required. Sump 1 and Sump 2 will be backfilled and re-graded to drain by gravity to Sump 3 which will be directed to the main basin of Snap Lake. Sump 4 will be backfilled and regraded to drain by gravity to Sump 5 which will be directed to the northwest arm of Snap Lake.

- Sump 3 and Sump 5 will be enlarged by excavation to become influent storage ponds (ISPs). They will be sized to store the volume of water from one open water season to equalize seasonal flows and concentrations prior to discharge either to Snap Lake directly, or to a constructed wetland.

**Passive Water Management Alternatives**

- As described in Section 4, water collected in the WMP is currently either pumped to the underground mine, treated by a modular RO WTP or, if treatment is not required to achieve EQC, influent can bypass the treatment system for discharge to Snap Lake. Prior to feasibility design, various passive and semi-
passive treatment technologies capable of replacing the RO WTP in Closure and Post-Closure were evaluated (Appendix L.1). Selection of the appropriate passive treatment technology required the identification of parameters of potential concern (POPC), which was completed using three related water quality models: the site water quality model, the Snap Lake hydrodynamic model, and the effluent quality criteria (EQC) model (Golder, 2019c).

- The site water quality model (Golder, 2019c) incorporates the site water balance and water quality data from the Snap Lake Environmental Database to predict concentrations of water quality parameters in Sump 3 and Sump 5 overflow. Concentrations of major ions and nitrate in Sump 3 and Sump 5 are anticipated to reduce over time due to flushing of the North Pile. Basic calculations indicate that flushing of mine-impacted water from the North Pile will require up to 30 years, and therefore a 30-year period (from 2020) has been considered in the base case plan (Golder 2018h).

- The Snap Lake hydrodynamic model (Golder, 2019c) was developed to simulate mixing of mine-affected inflows into Snap Lake and to estimate concentrations at the edge of the effluent mixing zones in both the main basin and northwest arm of Snap Lake.

- The EQC model (Golder, 2019c) integrates the predictions of the concentrations of water quality parameters in mine-affected inflows from the site water quality model with results of the hydrodynamic model. The results of the EQC model demonstrate that at the edge of the mixing zone, concentrations of all parameters are below low-action trigger levels (AEMP benchmarks minus 25%) of the updated AEMP benchmarks (Golder, 2019d) without application of water treatment, with the exception of nitrate. The EQC model estimates that an effluent quality criterion (maximum average) of 25 mg/L nitrate would be necessary to achieve the AEMP benchmark, and thus the closure objective SW3, in Snap Lake.

Key notes regarding modelling studies:

- Without the need to pump water from within the underground mine, the volume of water to be managed during ECM, Closure and Post-Closure is reduced. This also reduces the total dissolved solids content (and hardness) of the water, and has necessitated a review of the appropriateness of the current AEMP Benchmarks in Snap Lake (Golder, 2019d), and the EQC at points of discharge (Golder, 2019c).

- The water models are calibrated on the basis of on-site monitoring, and use 95th percentile results, which is considered reasonably conservative for all parameters.

- Specific for nitrate, the modelling does not incorporate all of the structural changes or geochemical mechanisms within the North Pile that would be reasonably expected to contribute to the reduction of nitrate concentrations over time. This includes:
  - regrading and covering the pile, which will introduce rock with lower concentrations of nitrate and promote runoff rather than infiltration flow paths;
  - aggradation of permafrost over time, which will lead to reductions in the volume of infiltration/seepage, and entrainment of nitrate in the frozen material; and
  - flushing of the pile over time, as there is a finite amount of nitrate within the pile.

There is confidence that these processes will contribute to reduced loadings, however quantification of these processes in the models is difficult to confidently predict and cannot be calibrated against current data. Monitoring at site has already shown reductions of nitrate in
Sump 1 and Sump 2 during ECM. As this monitoring continues, the results will inform final decisions around management and mitigation for nitrate.

- Based on the results of the EQC model, mitigation of nitrate concentrations in Sump 3 and Sump 5 overflow during Post-Closure is required. Passive treatment consisting of constructed wetlands engineered for nitrate removal has been selected as a passive technology capable of achieving required EQC. The current design basis for the passive treatment system has been based on the surface area (contact time) and volume (hydraulic retention time) required to treat the modeled influent load to the design effluent load (Appendix L.2). In addition to the nitrate EQC, limits related to TSS, pH and toxicity would also be retained. The existing RO WTP or a suitable alternative, and the existing EQC, would remain in place until the performance of the passive treatment system is demonstrated.

5.3.2.2 Engineering Work Associated with Selected Closure Activities

North Pile

Figure 5.5 illustrates the North Pile closure design. Development of the final geometry of the North Pile closure cover requires excavation of Cell 2 and Rib Berm 2 to accommodate placement of landfill waste material within a minimal footprint of the North Pile facility. Additionally, the western embankment at Cell 1 will be regraded to a 3H:1V slope to promote the long-term stability of the closure cover system.

As described in Golder, 2019a (Appendix H.1), the following construction sequence has been developed to be implemented during Closure to achieve the intent of the North Pile closure cover design. Construction activities may overlap and are listed in general progressive order:

1. **West perimeter embankment grading** – includes reducing the slope angle to 3H:1V while maintaining a cut to fill balance where practicable, constructing the Cell 1 channel outlet.

2. **West perimeter embankment erosion protection cover and riprap material placement** – includes placing erosion protection cover material atop the graded footprint and placing riprap material atop the erosion protection cover (functioning as a transition material to riprap) within the Cell 1 channel outlet.

3. **East Cell excavation/grading** – includes excavating Rib Berm 1, and deposited PK material from Cell 2, placing excavated fine PK material from Cell 2 into Cell 3, and local cut to fill grading.

4. **East Cell landfill waste material placement** – includes placing additional landfill waste material in Cell 1 and Cell 2 (see Section 5.3.4.2). Landfill waste material placement is assumed to occur through much of the duration of Starter Cell and west perimeter embankment closure cover construction activities.

5. **Starter Cell grading** – includes local cut to fill grading and constructing the Starter Cell swale.

6. **Starter Cell transition material placement** – includes placing transition material atop the graded footprint.

7. **Starter Cell erosion protection cover and riprap material placement** – includes placing erosion protection cover material atop the transition material and/or the graded footprint, and placing riprap material atop the erosion protection cover within the Starter Cell Swale. Under the riprap, the closure cover will function as an additional transition layer.
Figure 5.5  North Pile Cover Design
8. **East Cell transition material placement** – includes placing transition material atop the graded footprint and/or landfill waste material.

9. **East Cell erosion protection cover and riprap material placement** – includes placing erosion protection cover material atop the transition material and/or the graded footprint, and placing riprap material atop the erosion protection cover within the Cell 1 outlet channel and the East and West Swales.

Four different types of rock material are required for construction of the North Pile: transition, erosion protection cover, embankment, and riprap. All borrow materials are locally available; no off-site material will be required. Available borrow material sources are summarized in Table 5.5.

**Table 5.5 Borrow Sources**

<table>
<thead>
<tr>
<th>Borrow Area</th>
<th>Location</th>
<th>Primary Use</th>
<th>Available Quantity Estimate (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankment/rib berm</td>
<td>within North Pile</td>
<td>Erosion protection cover</td>
<td>29,000</td>
</tr>
<tr>
<td>Rib berms</td>
<td>within North Pile</td>
<td>Transition material</td>
<td>89,800</td>
</tr>
<tr>
<td>Crusher Stockpile</td>
<td>west of North Pile</td>
<td>Erosion protection cover material and/or transition</td>
<td>11,200</td>
</tr>
<tr>
<td>Explosive Management Bunker</td>
<td>west of East Cell</td>
<td>Erosion protection cover material and/or transition</td>
<td>1,700</td>
</tr>
<tr>
<td>Laydown Area</td>
<td>southeast of North Pile</td>
<td>Erosion protection cover</td>
<td>256,000</td>
</tr>
<tr>
<td>Organic Stockpile</td>
<td>former AN storage facility</td>
<td>Riprap</td>
<td>29,400</td>
</tr>
<tr>
<td>SP5 Quarry</td>
<td>North of East Cell, Cell 1</td>
<td>Erosion protection cover and/or transition material</td>
<td>68,200</td>
</tr>
<tr>
<td>West Cell Divider Dyke</td>
<td>North Pile West Cell</td>
<td>Embankment fill and/or erosion protection cover materials</td>
<td>81,000</td>
</tr>
</tbody>
</table>

The North Pile closure cover, embankment slopes, and surface water conveyance structures will be inspected by the geotechnical engineer to confirm stability and performance achieves design intent. An as-built report will be prepared by the engineer and provided to the MVLWB (see Chapter 9). Post-construction monitoring and maintenance are discussed in Section 5.5 below, and in the North Pile Management Plan (De Beers, 2019e).

**Water Management Systems**

Maps illustrating the flow of water during ECM (current system), Closure, and Post-Closure are presented in Figures 5.6 and 5.7. More detailed process flow diagrams and water management strategies are included in the proposed Water Management Plan (De Beers, 2019c).
Figure 5.6  Current (ECM) Water Management
Figure 5.7  Post-Closure Water Management

[Map showing post-closure water management systems]
**North Pile Drainage**

During ECM and early in Closure, North Pile drainage will continue to be collected in the perimeter sumps and pumped to the WMP for storage prior to treatment and discharge.

The five perimeter sumps will continue to be part of the water management system to achieve Post-Closure conditions. As part of Closure, the drainage channels connecting the sumps will be re-graded to allow gravity drainage (Sump 1 → Sump 2 → Sump 3; and Sump 4 → Sump 5). Designs for these channels are provided in Appendix L.1. Sump 3 and Sump 5 will be substantially modified, as they will form the influent storage ponds for the constructed wetlands (see Figure 5.7, and description below).

Establishing the Post-Closure ditch lines will require the following activities:

- characterization and handling of existing sediments that have accumulated in sumps (per Section 5.3.1.2);
- grading ditch lines to a slope that will not cause erosion, including blasting and excavation as required to establish grade, and use of erosion protection material; and
- contouring of side slopes to achieve design criteria for long-term stability.

Active revegetation of the North Pile drainage system is not planned. It is anticipated that over time, some vegetation encroachment will naturally occur. This has been taken into consideration in terms of the design of channel slope and capacity to ensure the ditch lines remain functional over the long-term without requirement for maintenance.

Earthworks will be inspected by an engineer to confirm stability and performance achieves design intent, and an as-built report will be prepared by the engineer. Post-construction monitoring and maintenance are discussed in Section 5.5 below.

**Water Management Pond**

The existing WMP will continue to be used during ECM to collect surface runoff and drainage from the North Pile and provide influent to the RO WTP. As part of Closure, the WMP will be repurposed and be integrated into one of the constructed wetlands. If the constructed wetland is found not to be required, this WMP area will be reclaimed, including characterization and handling of existing sediments that have accumulated, grading, and placement of engineered cover for physical stability, in accordance with the site wide closure activities described in Section 5.3.1.2.

**Constructed Wetlands**

Two constructed wetlands are planned to passively convey and treat nitrate in discharge from Sump 3 and Sump 5 to the main basin and the northwest arm of Snap Lake, respectively (Golder, 2019b). The wetlands will each have an influent storage pond (ISP) sized to store the volume of water from one open water season to equalize seasonal flows and concentrations. Excavation of the ISPs will include characterization and handling of existing sediments that have accumulated in Sump 3 and Sump 5 (per Section 5.3.1.2), and stockpiling of suitable fill material for the North Pile cover.
The ISPs will discharge passively at a controlled rate to the wetlands, which will then discharge to Snap Lake. The discharge channel has been designed such that fish passage from the lake to the wetland would be prevented under most flow conditions that would be expected to occur (Appendix L.2). Both constructed wetlands will be designed to treat nitrate to 25 mg/L at the point of final discharge (Appendix L.2). Process flow diagrams are shown in Figure 5.8. An emergency spillway has been included in the design of the ISPs to provide contingency discharge in the event that the passive wetland influent system becomes plugged.

It is acknowledged that it will take time for the wetlands to establish and mature to be able to achieve the expected performance objectives. The current construction sequencing places excavation of the ISPs and establishment of gravity drainage up-front, followed by construction of the wetlands. While the wetlands are being established and tested, the current RO treatment system (or a suitable alternative) and underground injection will remain in place to provide contingency treatment if required. It is expected that the maturation process will take approximately 5 years, although it may require longer.

The base case plan assumes that water treatment for nitrate will be required for a maximum of 30 years from the beginning of the Closure phase, after which site water quality is anticipated to meet EQCs untreated. Beyond this timeframe, the wetlands will no longer be required to achieve EQCs but will remain in place as a component of the environment.

Although the base case design includes the constructed wetlands, should water quality monitoring during the Closure period show that EQCs can be met at the ISP discharges, the wetlands will not be constructed and the emergency discharge locations for both ISPs will be modified for direct discharge into the environment.

Water Treatment Plant

The RO WTP, or an alternative appropriate configuration, will continue to be used during Closure to treat and discharge contact water as required. As contingency, the RO WTP (or alternative) will be available for use until such time that the performance of the passive treatment system has been validated or until drainage and runoff from the North Pile no longer requires treatment prior to discharge. The waste brines from the RO WTP will continue to be stored in the underground mine, using an existing pipeline, as deep as can practically be achieved.

5.3.3 Underground Mine Workings

5.3.3.1 Closure Alternatives

In early 2017, following reclamation activities to remove major structures and equipment and all hazardous materials from the underground mine workings (GNWT, 2017; De Beers, 2017f), the workings were flooded as part of Extended Care and Maintenance. Flooding reached steady state conditions with the local groundwater levels within three to four months. No future alternatives are currently contemplated for reclamation of the underground mine.

ICRP version 3.2 identified rock fill or reinforced concrete as potential options for sealing the portals and raises. Reinforced concrete was identified as the preferred option.
Figure 5.8  Process Flow Diagrams for Passive Treatment Wetlands

Source: Golder (2019b)
5.3.3.2 Engineering Work Associated with Selected Closure Activity

Flooded Mine Workings

Consistent with the approved Extended Care and Maintenance Plan (De Beers, 2018d), the underground mine was flooded between February and May 2017. The following were completed prior to flooding the underground mine (GNWT, 2017; De Beers, 2017f):

- Major structures and fixed and mobile equipment were removed from underground and stored on surface for cleaning, where necessary, for long term storage, or subsequent burial in the on-site landfill or off-site shipment.
- Any equipment or materials potentially contaminated with hydrocarbons or other hazardous materials were removed from underground or drained fluids and prepared for disposal as per the ECM Waste Management Plan.
- All fuel, lubricants hydraulic fluids, hazardous materials and degradable material were removed from the underground maintenance shops and secondary storage areas to surface, where it will be stored in appropriate containers and prepared for off-site shipment on subsequent winter roads.
- All explosives underground were exhausted.
- The only items that were left underground are non-degradable, constructed of steel, aluminum, vulcanized rubber concrete, or associated with utility lines including the conveyance system.

Access to the underground mine has been barred, all discharge of mine water has been stopped and the ventilation has been turned off to the underground workings.

Mine Portals

The two surface portals (one for the access ramp and one for the crushed ore conveyor) will be dismantled and sealed with reinforced concrete walls; details of the design are included in Appendix G.2. Once the portals are capped, inspected and signed-off, surface cuts at the portals will be backfilled to the general ground contour with surface quarried waste rock.

Raises

The ventilation raises will be capped with reinforced concrete. Details of the design are included in Appendix G.2. Once the raises are capped, inspected and signed-off, the surrounding area will be reclaimed to match the general ground contour.

5.3.4 Infrastructure

5.3.4.1 Closure Alternatives

Buildings and Equipment

Surface Facilities (General)

Based on stakeholder input and to reduce overall liability, all buildings and facilities will be removed from the site; no alternatives to this approach were considered.
To achieve the closure objectives related to chemical stability (e.g., SW1, I1, and I3), prior to demolition of any equipment or facility, all hazardous materials stored within them will be removed and prepared for off-site shipment. For the disposal of non-hazardous materials from demolished buildings and equipment, four alternatives were considered:

1. removal from site;
2. disposal in the underground workings;
3. disposal in the site landfill located within the North Pile; or
4. disposal in an expanded landfill to be located at the West Cell Airstrip Quarry.

Non-hazardous materials will be removed from site as the preferred closure option where this makes economic sense at the time of closure. De Beers will communicate with local businesses and communities to make them aware of materials and equipment that may be available to be repurposed for secondary use. Where materials are considered to have a re-sale value equal to or higher than the cost for the incremental labour and equipment effort for removal from site, these materials will be removed from site. Salvageable equipment is generally expected to include most machinery and mobile equipment in working or repairable condition.

Disposal of demolition materials within the underground mine is no longer a viable alternative as the underground workings have already been flooded (see Section 5.3.3).

The existing landfill located within the North Pile does not have capacity for the anticipated volume of inert demolition debris within the constraints of the North Pile final grading plan. Therefore, a demolition landfill will be developed within the East Cell of the North Pile by excavating deposited kimberlite to the extent required to accommodate the anticipated volume of inert demolition debris and closure cover. The excavated kimberlite would be used in reclamation of the North Pile. The demolition landfill is described further below, and in Golder, 2019a (Appendix H.1).

**Freshwater Intake and Treated Water Discharge Facilities**

ICRP version 3.2 outlined that reclamation measures for intake and discharge facilities will be designed in accordance with Federal standards for doing work in fish bearing waters and will be implemented following consultation with Fisheries and Oceans Canada and Environment Canada to ensure that the planned measures will be protective of aquatic habitat and will minimize the loss or alteration of habitat (e.g., rock filled embankments) created by these structures. These commitments remain unchanged.

As such, the intake structure will be partially removed to allow for the reclamation of the pumping apparatus, but much of the rock fill will be left in place (increasing available habitat) and no further alteration will occur. This is preferred to an alternative of complete removal, which would require in-water disturbance.

For reclamation of the outfall and diffuser to Snap Lake, four potential options have been evaluated to support the final closure plan:

1. Leave diffuser and outfall in place.
2. Leave the diffuser and pipe in place and fill the pipe with concrete or grout.
3. Pipe and diffuser removal.


Option 1 is not preferred, because residual risk remains. In the long term, the steel rods that hold the concrete weights together will corrode, and over time, the concrete weights could come apart and the HDPE pipe could rise to the surface. Option 3 would allow for a full walk-away solution, but would require shoreline disturbance during removal. Option 2 would address the risks identified in Option 1; and there is opportunity to fill the pipes using pieces of concrete from demolition works (rather than creating new risks associated with pouring concrete/grout in/near the lake). Option 4 would also address the in-water risk of Option 1, with a smaller amount of disturbance than Option 3.

Option 2 has been identified as the preferred option and has been incorporated into the Demolition Plan (see Section 5.3.4.2).

Transportation Routes

Alternatives for reclamation of transportation routes was previously evaluated (e.g., ICRP version 3.2), and remains unchanged.

Two alternatives were considered for reclamation of roadways and the airstrip, as follows:

- Leave “as is”; or
- Regrade and contour.

The “leave as is” concept was eliminated as not feasible due to the inclusion of structures such as culverts in these facilities that could degrade and ultimately lead to failures. These structures could have an adverse impact on the surrounding environment and may pose hazards to wildlife. This alternative would not achieve the reclamation objectives, was counter to stakeholder input, and was rejected from further consideration.

A closure concept of removing all culverts, regrading, and contouring the roads and airstrip to re-establish safe, gravity driven drainage that mimics natural drainage patterns was selected. This alternative was chosen for environmental reasons even though it is less cost effective.

Landfills and Other Disposal Areas

Landfilling will be completed within the footprint of the North Pile. This is preferred because it minimizes the disturbance footprint on the site, and minimizes reclamation effort because an engineered cover is already required in this area. The landfill has been directly incorporated into planning for closure of the North Pile (see Section 5.3.2).

It is currently expected that all non-salvageable non-hazardous wastes can be accommodated within the North Pile.

Where hydrocarbon contaminated soils are identified, they will be transported for temporary storage within lined area (re-purposed tank farm area), consistent with the Waste Management Plan (DeBeers, 2019b). Options for remediation will then be evaluated, which may include:
- Contaminated soil transferred off-site to an approved waste facility;
- Ex-situ Chemical Amendments (i.e., Chemical Oxidation);
- Landfarming (Bio-remediation);
- Soil Solidification/Stabilization (Low Temperature Asphalt/concrete); and
- Low Temperature Thermal Desorption.

The primary method for disposal of hydrocarbon impacted material will be to transfer the material off-site to an approved waste receiver. For any remediation conducted at the Snap Lake Mine, work will be conducted in accordance with the recommendations from the ESA (see Section 5.3.1.2).

5.3.4.2 Engineering Work Associated with the Selected Closure Activities

Buildings and Equipment

Demolition and disposal of all buildings and equipment will be completed by a Demolition Contractor in accordance with the Waste Management Plan.

Major structures for demolition include the Process Building, Utilities Complex, Services Complex, and Utilidor. In addition, Appendix G.1, Tables G.1-5 and G.1-6 include lists of the ancillary buildings, and other equipment/debris to be decommissioned as part of the work.

Common tasks that will be required for the decommissioning of buildings on site include:
- removal of utilities from the building;
- removal of hazardous materials for offsite transport;
- removal of all equipment, piping, and other items to facilitate the demolition of the structure (load, haul, and placement of the material in the on-site landfill);
- demolishing and hauling to the on-site landfill the building structure and any remaining items that were not removed as part of stripping work;
- removal of concrete above the slab-on-grade (SOG) elevation and creating holes in the SOG to promote drainage of precipitation into the subsurface;
- placement of a 0.5 m thick layer of fill material over all building foundations/SOGs and grading to match adjacent ground surface (fill material will be borrowed from site infrastructure features that are no longer required, such as a portion of the airstrip and laydown areas with considerable fill materials); and
- post-demolition evaluation and reporting.

These tasks are each relatively straightforward to implement; however, given the number of facilities, and seasonal time constraints, the demolition effort will be a complex logistics planning exercise, taking into account personnel transport/accommodations, and winter road requirements.

Unique closure planning aspects for individual buildings/equipment are described in sub-sections below.
**Accommodations**

To allow decommissioning of the existing accommodations complex, a fully independent, temporary camp that can accommodate the Demolition Contractor will be mobilized and commissioned for use during demolition activities.

The camp is planned to be located at Laydown 1, because it is a large, flat area that provides ample space for the camp buildings and facilities (generator, wastewater treatment plant, heated water storage, fuel storage), parking, and related support requirements, such as a lined Temporary Storage Area (TSA) for the collection, containerization, and storage of hazardous materials that require off-site transport and disposal.

These facilities will be removed from site once no longer required.

**Freshwater Intake and Treated Water Discharge Facilities**

The pipe/diffuser will be filled with concrete to weigh down the HDPE pipe. This component of decommissioning work will be scheduled to be completed during the fish timing window of July 16 to September 14; however, no disturbance to the shoreline or lake-bed is expected to be associated with this activity.

**Airport Laydown Area Buildings**

Existing buildings at the airport laydown will be decommissioned and demolished in accordance with the Demolition Plan.

As an interim step to support Post-Closure monitoring and long-term maintenance, two Winter Haven Buildings will be retrofitted to be used as a temporary camp. One Winter Haven will be retrofitted with sleeping quarters for up to 6 persons, along with kitchen and eating area in a second structure. An existing seacan with 60 KW generator will remain for minor electrical requirements for this camp and one of the existing Foldaway shops will be relocated to provide cold storage for a grader (and tools/critical spares). These facilities will be removed from site once no longer required.

**Piping and Cables**

With the exception of fuel and glycol piping, surface pipes will be removed to just below grade and ends will be capped where buried portions of pipes are left in place. Buried fuel and glycol lines will be flushed with water, removed and buried in the North Pile. Surface piping will be flushed, if necessary, removed and buried in the North Pile.

Buried electrical cables will be cut approximately 1 m below grade at surface terminations and the buried portions then left in place. All above ground cable will be removed and buried in the North Pile.

**Pads**

**Laydown and Gravel Pads**

Laydown areas and gravel pads that will remain after Buildings and Equipment have been removed from the area. Reclamation of these areas is described under the Site Wide considerations in Section 5.3.1.2.
Fuel Storage Areas

Any remaining diesel fuel inventory at site will be assessed against predicted requirements for temporary power generation and construction equipment during Closure. In the event of a shortfall, an additional supply will be delivered to site and stored in appropriate temporary holding to the end of Closure.

Demolition and disposal of the fuel storage areas will include:

- Prior to dismantling, each will be cleaned. Sludges will be pumped from the bottom of the tank and shipped off site for appropriate disposal. Steel plate sections and distribution system components will be washed.
- Tanks will be dismantled, with the steel cut up into sections and buried in the on-site landfill.
- The containment berm and liner materials will be removed. Liner materials will be cut into smaller strips and buried in the on-site landfill.
- Confirmatory soil sampling will be conducted; any contaminated materials will be addressed as part of the Environmental Site Assessment (see Section 5.3.1.2).
- Earthworks will be completed to re-grade/contour the area to match with the surrounding topography as per the Landform Design Plan.
- Revegetation Works will be completed as outlined in the Final Revegetation Plan (Appendix J.1), including scarifying, placement of overburden material (where appropriate), application of fertilizer, and seeding.

Transportation Routes

Site Roads

Site roads will be decommissioned and reclaimed at the end of Closure. Culverts or other crossing structures will be removed and replaced with swales to permit natural drainage to become re-established. As outlined in the Final Landform Plan (see Section 5.3.1.2 and Appendix G.3), these crossings will be suitably armoured with coarse rock and the side slopes graded to prevent ongoing erosion. Grading at these crossings will allow for continued vehicle passage into Post-Closure to support any monitoring or maintenance activities. The remaining reclamation of road surfaces will involve scarifying and loosening the top surface to facilitate natural revegetation, followed by revegetation in accordance with the Final Revegetation Plan (see Section 5.3.1.2 and Appendix J.1).

Winter Access Spur Road

It is anticipated that during Closure, at least two years of winter roads will be required. The Demolition Contractor will be responsible for the construction and maintenance of a winter road spur from the Tibbett to Contwoyto Winter Road Joint Venture to the Snap Lake site to mobilize/demobilize equipment and supplies required for the demolition execution, including the removal of hazardous materials on the backhaul.

Reclamation of the winter spur road following the final season of use will involve scarifying and loosening the top surface to facilitate natural revegetation.
Airstrip

The airstrip is 1,900 m long, and sized to accommodate C-130 Hercules and Boeing 737 or equivalent aircraft. Landing such aircraft will not be required Post-Closure; therefore the airstrip will be reclaimed near the end of Closure. Lighting, navigation equipment and culverts will be removed. The east portion of the airstrip may be used as a borrow source for fill material to support other reclamation activities.

Reclamation of the airstrip will involve scarifying and loosening the top surface to facilitate natural revegetation. Where erosion or sedimentation is a concern, the surface will be re-contoured. The three culverts will be removed and replaced with swales to permit natural drainage to become re-established. As required, and as outlined in the Final Landform Plan (see Section 5.3.1.2 and Appendix G.3), these crossings will be suitably armoured with coarse rock and the side slopes graded to prevent ongoing erosion.

Pits and Quarries

Historical Bulk Sample Pit

The historic bulk sample pit has been allowed to flood with water, forming a small pond. Water quality sampling of the existing pond indicates no long-term risk (De Beers, 2018b), therefore this pond will be left as-is.

Granite Quarries

Material from the West Cell Quarry will be used for the North Pile cover (see Section 5.3.2). Once the available rock from this quarry has been depleted, reclamation will be initiated. Any exposed bedrock will be inspected and scaled as required to ensure long-term physical stability. All mobile and stationary equipment will be removed, remaining material will be spread and contoured to blend with the surrounding landscape.

Similarly, at the West Cell Airstrip Quarry, any exposed bedrock will be inspected and scaled as required to ensure long-term physical stability. All mobile and stationary equipment will be removed, remaining material will be spread and contoured to blend with the surrounding landscape.

Once contoured, Revegetation Works will be completed as outlined in the Final Revegetation Plan (see Section 5.3.1.2, and Appendix J.1).

Landfills and Other Disposal Areas

Management of waste and waste facilities during the Closure period are summarized below, and described in further detail in the Waste Management Plan (De Beers, 2019a).

Hazardous Materials

Appendix G.1, Tables G.1-1 and G.1-2 summarize the current inventory (September 2018) of hazardous materials that are on site, which will require packaging, off-site transportation and disposal.
Solid Waste Disposal Facility

Appendix G.1, Table G.1-3 summarizes the estimated landfill volume requirement for inert wastes, which is 95,000 m³ of compacted material based on a bottom-up calculation. For conservatism, it is assumed that none of the demolition material is salvageable, however as described in Section 5.3.4.1, materials will be shipped off-site and re-purposed where economically feasible.

Non-salvageable and non-hazardous components, structures and equipment will be buried in the on-site landfill. Materials placed within the North Pile will be covered with a non-PAG engineered cover, as per approved design by a professional engineer and QA/QC protocol (see Section 5.2.5.1). This work will occur progressively to construct an engineered cover on each of Cell 1 to 5 (as applicable, depending on total airspace requirements) following placement of demolition materials to the final design elevation.

The current landfill and associated closure cover design is based on an estimated 114,000 m³ volume of landfill waste material. The estimated landfill waste volume carries an inherent uncertainty, and variations in the amount of landfill waste may result in variations in the final elevations of the cover. However, the overall flow conveyance strategy for the North Pile closure cover is robust, and can be maintained and adapted to variances in the design volume of landfill waste. Lower volumes of landfill waste can be accommodated to the current design with reduced or no excavation in Cell 2, while greater volumes can be accommodated with excavation of additional Cells and/or changes in grading.

Incinerator and Waste Transfer Storage Area

The incinerators, waste-handling equipment and associated structures will be dismantled and any salvageable equipment demobilized from site. The non-salvageable equipment and buildings will be cleaned of hazardous materials and then demolished with the demolition debris buried in the on-site landfill.

5.3.5 Summary of Climate Change Considerations

The potential effects of climate change have been considered in the development of closure and reclamation activities and designs, including contingency plans. Specific examples for key closure components are provided in the following sub-sections. Environmental monitoring will continue throughout Closure and into the Post-Closure phase, such that any unanticipated effects of climate change can be identified and addressed if required.

Water Quality

- Climate change was not expressly included in the site water quality model; however, the model implicitly accounts for climate change due to the assumption that groundwater flow and draindown occurs in an unfrozen North Pile. It is not expected that climate change will influence near surface freezing in the winter to the extent that it would alter current model assumptions. Increases in precipitation that may be expected in warmer climate conditions is expected to result in improvement in water quality due to increased amounts of clean surface water for dilution (Golder, 2019c).
- Sensitivity analyses on the water quality models are on-going and will be incorporated into final engineering design where applicable.
Site Physical Stability

- Site structure designs, including the North Pile, water management conveyances, and ISPs are not reliant on permafrost for stability. These structures are designed to remain stable under both permafrost and unfrozen conditions.

- Water conveyances, ISPs and the passive treatment system designs utilize an inflow design flood (IDF) based on the Probable Maximum Flood (PMF) as a design criteria. The CDA criteria for IDF at closed facilities with a ‘significant’ classification is the 1/3 between the 1,000-year event and the PMF. Using the PMF is more conservative than applying the CDA requirement, and thereby inherently accounts for uncertainty in the estimate that may be related to the influence of climate change.

- Spillways on the ISPs provide contingency release in case of higher than anticipated volume or plugging of the wetland influent pipe system. Site water quality is expected to meet EQCs without treatment approximately 20 years into the Post-Closure phase, and therefore wetland flow at the design flow rate is not required in perpetuity.

Vegetation / Revegetation

- Revegetation programs are designed to use local native species such that any response to climate change over the long term is expected to be consistent with that of the RSA.

- In the medium term, the warming temperatures and increased precipitation rates generally expected for the NWT are anticipated to be beneficial for on-going wetland and revegetated area development, such that closure criteria may be attained sooner than expected.

5.4 Predicted Residual Effects

Certain residual effects from the operation of the Mine are expected to occur despite all ongoing mitigation efforts and closure activities being completed. A detailed assessment of the potential residual effects was completed as part of the EAR (De Beers, 2002). A summary of the methods used for assessment, resulting EA predictions and residual effects currently predicted to occur for each identified negative residual impact of mining that was predicted to persist beyond completion of the planned final reclamation activities, is provided in Appendix D.2 for reference.

5.4.1 Atmospheric Environment

Air Quality

The EAR (De Beers, 2002) identified residual impacts associated with changes in SO₂, NO₂, TSP, PM₁₀, and PM₂.₅ concentrations to the ambient air quality, as well as changes to acid deposition. These were limited to the operations time period, reversible in less than 3 years, and impacts were predicted to have a negligible or low, environmental consequence.

Achieving the closure criteria outlined for closure objective SW1 (dust levels safe for people, vegetation, aquatic life and wildlife; see Table 5.3), will ensure that the conclusions from the EAR remain valid. This is further supported by air dispersion modelling completed for the ECM and Post-Closure phases (De Beers,
2019h), which shows that the predicted mass-loadings will be less than the NPRI and GNWT thresholds during the Post-Closure phase.

Noise

Noise-producing activities such as on-site construction activity, on-site equipment operation and air traffic are not expected to occur beyond the Closure phase. The environmental consequences of noise related impacts from the construction and operations phase were assessed to be negligible to low, and reversible within the timeline expected for the completion of closure activities. This conclusion remains valid.

5.4.2 Physical Environment

Stability

While not specifically assessed as a VEC in the EAR, long-term physical stability is a fundamental requirement in order to achieve closure objectives SW2 (drainage pathways for surface runoff are physically stable); SW4 (mine areas are physically stable and safe for use by people and wildlife); and NP2 (physically stable PK containment area to limit risk of failure that would affect safety of people or wildlife). To this end, stability analyses were performed at key locations on the North Pile to confirm the stability of the closure cover (Golder, 2019a and Appendix H.1). Results indicate the North Pile closure geometry and feasibility cover design satisfies the Canadian Dam Association and Anglo American standard’s minimum static and pseudo-static factor of safety requirements for the Post-Closure. For other areas on-site, the Final Landform Plan (Arktis, 2019c and Appendix G.3) outlines the design criteria to achieve these closure objectives. As such, residual effects are not anticipated.

Ground Thermal Regime

After Closure, the ground thermal regime is expected to return to a frozen condition. While conditions will differ from baseline, an active layer will be developed on an annual basis and permafrost will be re-established. The EAR considered the environmental consequence to be low to moderate.

Monitoring at site has shown that freezing of the pile is taking longer than the 3 years predicted in the EAR; however, freezing is still expected, and the current pile remains stable (DeBeers, 2017c). Even if complete permafrost were not to develop, the North Pile has been designed to be physically stable if the pile material is unfrozen (De Beers, 2002, Appendix H.2 & Golder, 2018e). As such, residual effects are not anticipated.

5.4.3 Chemical Environment

Water Quality

Water quality effects in Snap Lake have most recently been evaluated in the 2018 AEMP Re-evaluation Report (Golder, 2018a). This evaluation found that changes to water quality in Snap Lake and downstream are not expected to cause adverse effects to resident aquatic life, do not pose a human health risk, and have not adversely affected the drinkability of the water. Concentrations of most water quality parameters that had increased during Operations are decreasing in the main basin of Snap Lake during ECM, and are expected to continue to decrease during Closure and into Post-Closure.
Post-Closure water quality predictions have been updated to support development of the FCRP using three related water quality models: the site water quality model, the Snap Lake hydrodynamic model, and the effluent quality criteria (EQC) model. The site water quality model incorporates the site water balance and water quality data from the Snap Lake Environmental Database to predict concentrations of water quality parameters over a period of approximately 30 years. The EQC model integrates the predictions of site water quality model with results of the hydrodynamic model, and demonstrates that at the edge of the mixing zone in Snap Lake concentrations of all parameters are below low-action trigger levels (75%) of the updated AEMP benchmarks without application of water treatment with the exception of nitrate. The EQC model estimates that an effluent quality criterion of 25 mg/L nitrate would be necessary to achieve the AEMP benchmark. Current predictions of nitrate at Sump 3 and Sump 5 are estimated to be 50 to 60 mg/L, but are anticipated to reduce over time due to installation of the engineered cover and permafrost aggradation. Water is currently being treated through the RO WTP prior to discharge and this will continue through Closure, but is not the long-term solution. A passive water treatment system is planned to provide the necessary level of removal if nitrate levels do not decline naturally.

Achieving the closure criteria outlined for closure objective SW3 (surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife; see Table 5.3), will ensure that the residual effects conclusions from the EAR remain valid.

5.4.4 Biological Environment

Aquatic Resources

In the EAR, residual effects were assessed for non-fish aquatic organisms (phytoplankton, zooplankton and benthos) in Snap Lake, North Lake, Northeast Lake, NL5, and NL6. Negligible to moderate magnitude impacts that are reversible over the long term (greater than 30 years) were predicted.

The results from the 2018 AEMP Re-evaluation Report (Golder, 2018a) suggest that the discharge of treated Mine effluent is not adversely affecting aquatic resources in Snap Lake. Because the discharge of treated effluent has been greatly reduced during ECM, and will remain so through Closure and into Post-Closure, lake water quality and biological conditions are expected to return to near-baseline over time. This is supported by updated water quality modelling predictions to support the FCRP. Therefore the residual effects conclusions of the EAR remain valid.

Fish

The EAR evaluated residual effects to fish habitat (negligible to low in magnitude and reversible in the short term (by the completion of closure activities)); fish health (negligible magnitude impacts to the chronic effects on fish health in Snap Lake), and fish abundance (low to moderate magnitude that are reversible over the long term (greater than 30 years).

The 2018 AEMP Re-evaluation Report (Golder, 2018a) shows that operation of the Mine has resulted in minimal changes to the fish community in Snap Lake, which is consistent with EAR predictions. The closure activities outlined in the FCRP continue to support the residual effects conclusions of the EAR.
The wetland discharge channel has been designed to prevent fish passage into the wetland under most flow conditions that would be expected to occur and therefore no effects to fish as a result of the passive treatment system are predicted.

**Vegetation and Wildlife**

Changes to the terrain units present within the local study area were expected to be high in magnitude and irreversible. These impacts were primarily due to site clearing activities to facilitate the construction of Mine infrastructure, and assume alteration of the entire project footprint. The EAR predicted loss of 559.5 ha within the LSA. As of 2018, the total land disturbance associated with the Project within the LSA was 188 ha (Arktis, 2019c). The current land disturbance area, plus the additional disturbance resulting from the construction of the closure water management systems, is less than the predicted disturbance area from the EAR, and therefore the conclusions with respect to residual effects related to ELC Units, Rare Plant Potential, Traditional Plant Potential, Biodiversity, and Vegetation Health remain valid.

Eight wildlife indicator species were selected for study of residual impacts to wildlife habitat, movement and behaviour, and abundance within the EAR.

Residual effects were predicted to occur to wildlife habitat from both direct and indirect linkages. Direct impacts include site clearing activities within the Project footprint, indirect linkages may include negative impacts to vegetation in the LSA which results in the loss of wildlife habitat. Residual effects were considered to be of negligible to low magnitude, and were considered reversible in the long term (100 years).

Residual effects related to wildlife movement, behavior, and abundance were considered low to negligible in magnitude during construction and operation, and were expected to be reversible by the completion of closure activities.

The closure activities outlined in the FCRP continue to support the conclusions of the EAR. A combination of active and passive revegetation is planned, which over the long-term will progress toward conditions reflective of the surrounding area. Post-Closure conditions will be an improvement from the current status, and effects to wildlife due to loss of habitat have not been observed as a result of Operations.

**5.4.5 Resource Use**

**Heritage Resources**

Direct impacts from activities related to the construction of the mine site and associated infrastructure, including the winter roads and esker quarry, had the potential to impact heritage resources. The results of the archaeological studies completed prior to, and as part of the EAR indicated that, provided development continued as planned, no heritage resources were likely to be encountered during construction and operation of the mine.

Given that heritage resources have not been encountered to date at the Mine, it is considered unlikely that Closure activities would now encounter something new. As such, the residual effects conclusions of the EAR remain valid.
Traditional Land Use

Residual effects to traditional land uses were expected to be limited to the construction and operation phases of the mine and will not extend beyond completion of closure activities. The closure activities outlined in the FCRP, including ongoing engagement with Traditional Knowledge holders and local communities, will continue to support the residual effects conclusions of the EAR.

Non-Traditional Resource Use

In the EAR, residual effects to domestic hunting, commercial and recreational fishing, recreation and tourism, permanent and seasonal camps, subsurface mineral resources exploration and extraction were not expected beyond the completion of closure activities. The closure activities outlined in the FCRP continue to support the residual effects conclusions of the EAR.

Aesthetic Quality

Residual effects of infrastructure, steam plumes, the North Pile and site lighting are not expected to extend beyond the operations phase. Only the North Pile will remain following completion of mitigation measures (closure activities) at the Mine, which will involve covering the PK with local quarried materials, contouring, and limitations on the final height of the pile in order to blend with the surrounding landforms.

The closure activities outlined in the FCRP, and closure objective SW5 (Landscape features (shape and vegetation) match aesthetics of the surrounding natural area) continue to support the residual effects conclusions of the EAR.

Tibbitt-Contwoyto Winter Road

Residual effects of the Project on the Tibbitt-Contwoyto winter road are not expected to continue following completion of closure activities. The closure activities outlined in the FCRP continue to support the residual effects conclusions of the EAR.

5.5 Post-Closure Monitoring, Maintenance and Reporting

Environmental monitoring has been conducted on and near the Mine site throughout the life of the Project. This monitoring has been used to support exploration and early planning, environmental assessments, construction management, operational decision-making, adaptive management, and closure planning. The key results of monitoring conducted to date are described in Section 3.

This section presents the planned Closure and Post-Closure monitoring, maintenance and reporting program. The closure monitoring program will serve to assess the performance of the closure measures, inform remedial and corrective actions, and demonstrate the overall stability of the site in accordance with the closure goal and objectives. As described by the MVLWB:

“The primary purpose of Post-Closure monitoring is to determine whether closure criteria have been met, and therefore that closure objectives and the closure goal have been achieved. The implementation of a successful monitoring program, which will likely begin during the exploration stage and continue during operations through"
Post-Closure, will help the proponent demonstrate that relinquishment can occur.”
(MVLWB et al., 2013).

The Post-Closure phase begins once active management of the site is no longer required and activities consist solely of monitoring and potential associated contingency actions. The scope, duration and frequency of Post-Closure monitoring efforts have been informed by the various monitoring programs executed during Exploration, Operations and ECM. Most closure criteria require a minimum of 3 - 5 years of monitoring data (depending on the criterion) in order to demonstrate completion of closure objectives; however, for project planning purposes Post-Closure monitoring is conservatively anticipated to continue for a minimum of 20 years. Following the initial 5 years of Post-Closure, if results indicate that closure objectives have not yet been achieved, then monitoring will continue with gradually reducing scope and frequency for up to 20 years. Beyond this point, which is equivalent to approximately 30 years from the start of the Closure phase, it is anticipated that site water quality will meet EQCs without treatment (Golder, 2019c) and that monitoring will no longer be required.

In addition to active on-site monitoring, De Beers has installed video surveillance equipment to provide continuous surveillance from Gahcho Kué Mine during periods that the site is not occupied. This surveillance is focused upon water control structures and human or wildlife activity.

The closure design for the surface facilities incorporates features to minimize future maintenance requirements. For example, all sites will be graded to limit surface ponding, and drainage channels will be designed to prevent sedimentation and erosion. No permanent buildings will remain, eliminating any maintenance requirements associated with structures. All pumping systems will be removed and natural drainage pathways will be established, where possible. Other than activities associated with environmental monitoring and inspections, no planned Post-Closure maintenance activities are expected.

Annual routine maintenance will be required for the passive water treatment system during the Closure phase but once the wetlands reach maturity, no additional maintenance is anticipated. The system will be inspected annually in the early years of Post-Closure. Maintenance and inspection requirements are described in more detail in the passive treatment system design report (Appendix L.2).

In situations where on-site or remote monitoring and inspection detect degradation, instability or issues that required further attention, maintenance will be completed to rehabilitate the specific structure to its functional and safe condition. Trigger-action-response plans (TARPs) will remain in place for monitoring programs to direct appropriate actions when required. De Beers recognizes that some unexpected Post-Closure issues could arise. Any such works would likely be small in size, able to be constructed in a cost-effective manner using resources brought to site by aircraft. Potential contingency actions are described in more detail in Section 5.6.

All sampling and analysis will be conducted in accordance with the QA/QC Plan (De Beers, 2019d) required under the Water Licence. All analyses will be completed in off-site accredited laboratories with only sample preparation, where required, occurring on site.

The results of Closure and Post-Closure monitoring and maintenance will be reported according to requirements specified by permits, licenses and/or authorizations in place at that time. Any associated risks noted during monitoring or maintenance will also be reported. A reporting framework is proposed in
the following sections and further discussed in Section 9. Monitoring results will generally be reported in annual reports required under the Water Licence. Construction reporting, including as-buils and the results of QA/QC programs, will be reported in Reclamation Completion Report(s), while ultimate achievement of closure objectives will be demonstrated through Performance Assessment Report(s).

The planned Post-Closure monitoring programs and the associated closure objectives are listed in Table 5.6 and summarized in the following sub-sections.

Table 5.6 Snap Lake Monitoring Programs

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Closure Objectives</th>
<th>Closure Reporting</th>
<th>Post-Closure Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Quality, Meteorology and Emissions Monitoring</td>
<td>SW1 – Dust levels safe for people, vegetation, aquatic life and wildlife</td>
<td>Air Quality, Meteorological Monitoring and Emissions Reporting Annual Report NPRI reporting (when triggered)</td>
<td>None</td>
</tr>
<tr>
<td>Geotechnical Monitoring</td>
<td>SW2 – Drainage pathways for surface runoff are physically stable.</td>
<td>Post-construction monitoring and maintenance reports</td>
<td>Post-construction monitoring and maintenance reports (as required)</td>
</tr>
<tr>
<td></td>
<td>SW4 – Mine areas are physically stable and safe for use by people and wildlife.</td>
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<tr>
<td></td>
<td>SW6 – Safe passage and use for Caribou and other wildlife.</td>
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<tr>
<td></td>
<td>NP1 – Prevent PK from entering the surrounding terrestrial and aquatic environment.</td>
<td></td>
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<tr>
<td></td>
<td>NP2 – Physically stable PK containment area to limit risk of failure that would affect safety of people or wildlife.</td>
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<td></td>
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<tr>
<td></td>
<td>UG3 – Underground mine workings are physically stable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrological Monitoring</td>
<td>SW2 – Drainage pathways for surface runoff are physically stable.</td>
<td>Reported with AEMP</td>
<td>Reported with AEMP</td>
</tr>
<tr>
<td></td>
<td>SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SW4 – Mine areas are physically stable and safe for use by people and wildlife.</td>
<td></td>
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</tr>
<tr>
<td>Monitoring Program</td>
<td>Closure Objectives</td>
<td>Closure Reporting</td>
<td>Post-Closure Reporting</td>
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</tr>
<tr>
<td>Surveillance Network Program</td>
<td>SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife. UG2 – Underground mine should not contribute to the contamination of ground or surface water. I1 – Prevent remaining infrastructure from contaminating land or water I3 – Contaminated soils and waste disposal areas that cannot contaminate land and water.</td>
<td>Water Licence Annual Report</td>
<td>Water Licence Annual Report (for 3 years Post-Closure)</td>
</tr>
<tr>
<td>Aquatic Effects Monitoring Program</td>
<td>SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife. I1 – Prevent remaining infrastructure from contaminating land or water UG1 – Flooding of the underground mine will have no impacts to aquatic habitat and community in source lakes. UG2 – Underground mine should not contribute to the contamination of ground or surface water.</td>
<td>AEMP Report</td>
<td>AEMP Report (3 years Post-Closure)</td>
</tr>
<tr>
<td>Vegetation Monitoring Program</td>
<td>SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area. SW7 – Revegetation targeted to priority areas.</td>
<td>Annual Closure and Reclamation Report</td>
<td>Annual Closure and Reclamation Report (for 5 years Post-Closure)</td>
</tr>
<tr>
<td>Revegetation Monitoring Program</td>
<td>SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area. SW7 – Revegetation targeted to priority areas.</td>
<td>Annual Closure and Reclamation Report</td>
<td>Annual Closure and Reclamation Report (for 5 years Post-Closure)</td>
</tr>
<tr>
<td>Passive Water Treatment Operational Monitoring</td>
<td>SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife.</td>
<td>Include within SNP (once system operational)</td>
<td>Include within SNP</td>
</tr>
</tbody>
</table>
### 5.5.1 Atmospheric Environment

#### Air Quality

The ECM air quality and emissions monitoring currently on-going at the Mine will continue throughout the Closure phase to demonstrate completion of Closure Objective SW1 (dust levels safe for people, vegetation, aquatic life and wildlife; see Table 5.3). Monitoring will include PM$_{2.5}$, dustfall, NO$_2$ and SO$_2$. Further details regarding sampling locations and frequencies are provided in the Air Quality and Emissions Monitoring and Management Plan (De Beers, 2019h).

The results of monitoring and any required maintenance will be reported within the Air Quality, Meteorological Monitoring and Emissions Reporting Annual Report.

The NPRI reporting thresholds are anticipated to be exceeded during the Closure phase, such that annual NPRI reports will be required. NPRI reporting thresholds are not anticipated to be reached during the Post-Closure phase (De Beers, 2019h).

#### Meteorology

Meteorological monitoring via the automated weather stations (Hill Meteorological Monitoring Station and Lake Hydro-Meteorological Monitoring Station) will continue throughout Closure. These data and any required maintenance will be reported in the Air Quality, Meteorological Monitoring and Emissions Reporting Annual Report.

### 5.5.2 Physical Environment

#### Geotechnical

Geotechnical inspections and instrumentation will be the key mechanisms for monitoring site physical stability during Closure and Post-Closure. These measures will be used to demonstrate achievement of physical stability-related closure objectives SW2 (drainage pathways for surface runoff are physically stable); SW4 (mine areas are physically stable and safe for use by people and wildlife); SW5 (landscape features (shape and vegetation) match aesthetics of the surrounding area) and NP2 (physically stable PK containment area to limit risk of failure that would affect safety of people or wildlife).

The North Pile closure cover, embankment slopes, and surface water conveyance structures (i.e., swales, channel outlets) will be inspected by the geotechnical engineer to confirm stability and performance achieves the design intent (De Beers, 2019e). This monitoring will include visual inspection and review of data obtained from instrumentation on the North Pile. Areas of visible closure cover erosion, instability of the embankment slopes, or areas of ponded water or obstructed conveyance will be documented, and maintenance or corrective action will be implemented in accordance with the plan. Instrumentation to be installed in the North Pile following cover placement will monitor thermal conditions, piezometric levels, and settlement. During Closure, the North Pile will be managed in accordance with the proposed North Pile Management Plan (De Beers, 2019e).
Post-construction monitoring and maintenance inspections will be continued for a minimum of 3 years following construction of the North Pile cover, embankments, and water conveyances. The report will summarize all data collected, observations, and corrective action for the North Pile from the previous reporting period.

The Landform Design Plan addresses stability in other areas of the site, including the Mine Site and Quarry, through contouring of slopes and disturbed areas (Arktis, 2019c). Areas which undergo landform stabilization during Closure will be monitored to confirm stability and performance through annual site-wide geotechnical inspection for a minimum of three years into the Post-Closure phase. The results of these inspections and any related maintenance will be provided in the Annual Closure and Reclamation Plan Progress Report.

The final landscape will also be monitored through a site visit by the Snap Lake Environmental Monitoring Agency (SLEMA) to confirm that landscape features are generally in alignment with the regional area. De Beers will also support community visits when requested by the communities.

**Hydrology**

Hydrological monitoring during Closure and Post-Closure will consist of water level measurements in Snap Lake; these will be performed and reported as a component of the AEMP. Measurements in North Lake, Northeast Lake, and 1999 Reference Lake have been discontinued during ECM and will remain so during subsequent phases since potential gains/losses due to the Mine are significantly reduced compared to Operations.

**5.5.3 Chemical Environment**

**Water Quality**

Water quality monitoring during Closure and Post-Closure will be executed through the Surveillance Network Program (SNP) and the Aquatic Effects Monitoring Program (AEMP). These results will be used to demonstrate achievement of water-related objectives as shown in Table 5.6.

The SNP is a requirement of the Water Licence and consists of site-wide water quality and quantity monitoring, with the objective of demonstrating that EQC are being and will continue to be consistently met. ECM monitoring under the SNP also includes locations at end-of-pipe and in the mixing zone in Snap Lake. The Closure and Post-Closure SNP has been updated primarily to discontinue monitoring of the underground mine water, reduce sampling of uncontrolled surface runoff, reduce sampling in the diffuser zone, and add sampling stations associated with the passive water treatment system and in the mixing zones in the main basin and northwest arm of Snap Lake (De Beers, 2019c).

An extensive AEMP for the Mine was developed during Operations. It was updated in 2015 when mining ceased and the Mine entered Care and Maintenance. The AEMP has been further updated as the 2019 Design Plan (Golder, 2019d) to determine the potential effects of the closed mine on the receiving environment, Snap Lake, evaluate the efficacy of mitigation measures, and identify the need for additional mitigation measures in order to avoid adverse environmental effects.
During Closure, water quality samples and field profiles will be collected at nine stations in Snap Lake: two diffuser stations, four main stations, the outlet of Snap Lake and two northwest arm stations. The same stations will be monitored during Closure as during Care and Maintenance, except for one less northwest arm station and one less diffuser station. A small reduction in stations is proposed because of the lower volumes of discharge and higher quality of the treated discharge from the RO treatment. To characterize reference conditions, water quality and field profiles will be collected at a subset of three stations in Northeast Lake, and a fourth deep station will be profiled at Northeast Lake. The diffuser stations in Snap Lake will continue to be sampled monthly during discharge, and once under-ice every three years. Other Snap Lake stations and the four Northeast Lake stations will be monitored once annually during open-water or two times a year (once under-ice and once during open-water) every three years.

During Post-Closure, the discharge location of treated effluent will be moved to a different location in the main basin and a new discharge will be in the northwest arm, which will result in two new mixing zones. Water quality samples and profiles will be collected annually during open-water conditions at eight stations in Snap Lake: four mixing zone stations, two main basin stations, the outlet of Snap Lake and one station in the northwest arm. Within the first three years of Post-closure, one ice-covered program covering Snap Lake and Northeast Lake, and one open-water program in Northeast Lake will be conducted to support the biological program.

Annual water quality monitoring in Snap Lake under the AEMP will continue for at least three years during Post-Closure. After three years of monitoring during Post-Closure, monitoring will only continue if increasing trends in water quality concentrations Snap Lake are identified. After three years or later, when concentrations in Snap Lake have stabilized or show decreasing trends, monitoring in Snap Lake will be discontinued. Annual water quality monitoring downstream of Snap Lake will continue during Post-Closure until concentrations of TDS have stabilized or are decreasing at both the outlets of Lac Capot Blanc and in MacKay Lake. In Post-Closure, water quality monitoring results relative to Low Action Trigger Levels will be used to identify if additional aquatic resources monitoring is required.

Water quality monitoring results will be reported within the Water Licence Annual Report.

**Sediment Quality**

The objective of the sediment quality monitoring is to determine whether sediment quality in Snap Lake can continue to support a healthy benthic invertebrate community. This monitoring compares concentrations of substances in the sediment with AEMP benchmarks. Sediment quality in Snap Lake will be assessed and compared to Northeast Lake. During Closure, sediment quality monitoring at a mixing zone station and other sediment stations will be carried out at least once. If sediment quality, benthic invertebrates, toxicity or water quality do not trigger a Low Action Level, no further sampling will occur during Closure. During Post-Closure, if the water quality or toxicity results suggest toxicological impairment or nutrient enrichment (based on Action Levels, trends in nutrients, metals and dissolved oxygen), sediment monitoring will be re-considered.

Further details on the SNP and AEMP, including sampling locations, frequencies, and trigger levels, are included in the Water Management Plan (De Beers, 2019c) and the AEMP Design Plan (Golder, 2019d).
5.5.4 Biological Environment

Aquatic Resources

Monitoring of aquatic resources is conducted within the AEMP framework and is intended to demonstrate achievement of aquatic-related closure objectives, including confirming that any effects from North Pile, infrastructure and underground components are minimized (Table 5.6).

Toxicity testing of treated effluent will be performed once per year during discharge (Golder, 2019d) until 3 years Post-Closure. The mine does not plan to discharge treated effluent in winter, so under ice-cover toxicity samples are not required.

There will be five plankton and benthic invertebrates sampling locations in Snap Lake and five in Northeast Lake. Sampling will be carried out at least once during Closure. During Post-Closure, if water quality or toxicity results suggest toxicological impairment or nutrient enrichment, monitoring will be re-considered.

The fish health program, which focuses on small-bodied fish (Lake Chub), will not change from previous years. A fish health program and fish tissue program will be carried out at least once during Closure. During Post-Closure, if water quality or toxicity results suggest toxicological impairment or nutrient enrichment, a fish health and tissue chemistry program will be re-considered.

Monitoring results will be reported within the AEMP report.

Further details on the AEMP, including sampling locations and frequencies, are included in the AEMP Design Plan (Golder, 2019d).

Vegetation

Vegetation monitoring will be used to confirm EAR predictions related to loss and/or alteration to native vegetation communities by tracking area of impact and ELC areas; while Re-Vegetation monitoring will be used to confirm as-constructed conditions and monitor performance to demonstrate achievement of revegetation-related objectives as shown in Table 5.6.

Vegetation Monitoring

The Vegetation Monitoring Program (De Beers, 2019f) is a requirement of the Environmental Agreement, and includes four studies:

- Area of Impact Monitoring Program;
- Ecological Land Classification (ELC) Area Monitoring Program;
- Passive Regeneration Monitoring Program; and
- Vegetation Dustfall Monitoring Program.

As reclamation activities associated with establishing the ISPs and constructed wetlands may generate new land disturbance, the area of impact and ELC area programs, which evaluate disturbance/loss using satellite imagery, will continue at 5 year intervals during Closure and into Post-Closure.
The passive regeneration program was conducted in 2018 as part of ECM. The program will be terminated moving forward as re-vegetation planning is sufficiently advanced for final closure.

As described in Section 5.5.1, dustfall monitoring will be conducted during the closure phase. The vegetation dustfall program, which includes vegetation and soils analysis from sites adjacent to dustfall monitoring sites, was conducted in 2018 as part of ECM. This program will be conducted once more 5 years into Post-Closure.

**Re-vegetation Monitoring**

Monitoring undertaken during revegetation activities to assess as-constructed conditions will include sampling of soil particle size and chemistry. As-constructed documentation will be developed to demonstrate conformance with the design, including areas scarified, fertilized and/or overburden placed, as well as rates of fertilizer and seed application, and overburden soil thickness (Appendix J.1).

The focus of the re-vegetation monitoring during Post-Closure is to measure the success of revegetation methods in meeting the closure objectives and associated closure criteria. The results of the monitoring will also be used to inform the adaptive management strategies, as presented in Section 5.6.

Reclamation sample plots will be established to measure plant cover within each of the following reclamation areas:

- Areas scarified, fertilized and seeded;
- Areas scarified, overburden applied, fertilized and seeded; and
- Natural revegetation areas.

The reclamation sample plots will be monitored for various parameters (see Appendix J.1) annually for the first five years. If after five years the closure criteria are not achieved, the reclamation plots will be monitored on a five-year period until the closure criteria are achieved. The frequency of re-vegetation monitoring is subject to change pending results, trends, and regulatory requirements.

The results of the re-vegetation monitoring program and any remedial actions taken will be documented in the Annual Closure and Reclamation Report.

**Wildlife**

Monitoring and reporting in accordance with the Wildlife Effects Management Plan (De Beers, 2019g) will continue through Closure and for three years into the Post-Closure phase. During Post-Closure, monitoring will continue only when personnel are on-site, which corresponds to the period when wildlife effects may be anticipated. The WEMP facilitates monitoring of wildlife presence at and immediately adjacent to the Mine through incidental observations and reporting of wildlife interactions. Any effects to wildlife habitat are also monitored through measurement of vegetation loss during closure activities (via the Vegetation Monitoring Program) and through monitoring of wildlife use of reclaimed areas.

Wildlife monitoring results, including any wildlife incidents (interactions and required management response), will be reported annually through the WEMP annual report.
5.5.5 Resource Use

Programs to monitor progress towards environmental objectives that support resource use, such as SW5 (landscape features (shape and vegetation) match aesthetics of the surrounding natural area) and SW6 (safe passage and use for Caribou and other wildlife), include a site visit by the SLEMA and fish tasting, if requested by the community, as a component of the AEMP. These programs are expected to continue through Closure and to conclude by Year 3 of Post-Closure.

5.6 Contingency Plan

The Post-Closure monitoring programs outlined in Section 5.5 include mechanisms for contingency response and corrective action, in the form of Trigger-Action-Response Plans (TARPs). These mechanisms build off the existing monitoring response framework that was established during mine operation, and later modified for ECM. An overview of the monitoring response framework for the mine is provided in Figure 5.9.

Figure 5.9 Overview of Monitoring Response Framework
To support development of this FCRP, the action levels and management responses have been reviewed and updated to align with the closure criteria in order to ensure that the closure objectives will be achieved. Table 5.7 provides a summary of the closure objectives/criteria, and the potential corrective actions that could be taken if monitoring programs indicate conditions are trending away from design. As well, the table includes cross-references to the appropriate monitoring programs where further details regarding the specific trigger levels and associated action response are developed. It is acknowledged that the potential corrective actions are high-level statements; where a trigger level is exceeded, the specific response plan will always be case-specific, and will require evaluation and recommendations from the appropriate qualified professional.
Table 5.7 Potential Corrective Actions

<table>
<thead>
<tr>
<th>Objective</th>
<th>Criteria</th>
<th>Key Monitoring Programs (cross references to Response Frameworks in bold font)</th>
<th>Potential Corrective Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1 – Dust levels safe for people, vegetation, aquatic life and wildlife</td>
<td>Ambient air quality shall not exceed the Northwest Territories Ambient Air Quality Standards (NWTAQGs) as demonstrated by monitoring during closure. Dustfall shall not exceed the Alberta Ambient Air Quality Guidelines (AAAQG) as demonstrated by monitoring during closure.</td>
<td>Air Quality and Emissions Monitoring and Management Plan (De Beers, 2019h, see Section 4 for Response Planning)</td>
<td>Identify source of dust. Reshape and reseed areas as required. Install wind breaks, if required.</td>
</tr>
<tr>
<td>SW2 – Drainage pathways for surface runoff are physically stable.</td>
<td>Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A) Annual Site-Wide Geotechnical Inspections</td>
<td>Identify source of erosion and redirect/disperse energy. Repair areas of visible erosion. Flatten/support areas of unstable slopes. Steepen/regrade areas of ponded water or obstructed conveyance. Re-seed areas as required. Install sediment control structures, if required.</td>
</tr>
<tr>
<td>SW3 – Surface runoff and seepage water quality that is safe for people, vegetation, aquatic life, and wildlife.</td>
<td>Meet Effluent Quality Criteria (EQCs) in surface discharge to achieve in-lake site specific water quality objectives (SSWQOs) as described in the approved MV/LWB Water Licence and demonstrated by Post-Closure monitoring for a period of 5 years after construction.</td>
<td>Surveillance Network Program Hydrology Monitoring Plan Aquatic Effects Monitoring Program (Golder, 2019d, see Section 8 for Response Framework)</td>
<td>Continue to operate water treatment systems or alternatives during wetland development. Inject water to underground wetlands if required. Contingency flow over ISP spillways to drain to Snap Lake if wetland influent is plugged. Human Health and Ecological Risk Assessment to assess potential effects if guidelines are not met.</td>
</tr>
<tr>
<td>SW4 – Mine areas are physically stable and safe for use by people and wildlife.</td>
<td>Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A) Annual Site-Wide Geotechnical Inspections Wildlife Effects Monitoring Plan</td>
<td>Repair areas of visible erosion. Flatten/support areas of unstable embankment slopes. Steepen/regrade areas of ponded water or obstructed conveyance. Re-seed areas as required.</td>
</tr>
<tr>
<td>SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area.</td>
<td>Final grading will reflect surrounding topography (i.e., steep edges of pits and trenches flattened or backfilled) with slopes of 3:1 where possible through engineering design. Natural drainage pathways will be re-established, where possible. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>Revegetation Execution Monitoring Revegetation Post-Construction Monitoring (Appendix J.1, see Section 7.0 Adaptive Management Strategies) Annual Geotechnical Inspections Site Visit with SLEMA</td>
<td>See actions for SW2 and SW4. Reshape and reseed areas as required.</td>
</tr>
<tr>
<td>SW6 – Safe passage and use for Caribou and other wildlife.</td>
<td>Where possible through engineering design, a 3:1 slope in mine-impacted areas will be achieved to facilitate caribou passage. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A) Annual Site-Wide Geotechnical Inspections Wildlife Effects Monitoring Plan Site Visit with SLEMA</td>
<td>See actions for SW2 and SW4. Reshape and reseed areas as required.</td>
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<tr>
<td>SW7 – Revegetation targeted to priority areas.</td>
<td>Revegetation activities, including scarification, soil preparation, and seeding, shall be successfully completed at priority areas to promote natural recovery. Priority areas are defined as the mine building and main laydown area. A 5% mean plant coverage on upland areas is targeted within 5 years of seeding as measured by Post-Closure monitoring, resulting in a mean plant coverage of 29.5% over the LSA.</td>
<td>Revegetation Execution Monitoring Revegetation Post-Construction Monitoring (Appendix J.1, see Section 7.0 Adaptive Management Strategies)</td>
<td>Reshape and reseed areas as required.</td>
</tr>
<tr>
<td>Objective</td>
<td>Criteria</td>
<td>Key Monitoring Programs</td>
<td>Potential Corrective Actions</td>
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<tr>
<td>NP1 - Prevent PK from entering the surrounding terrestrial and aquatic environment.</td>
<td>a) Closure design of engineered structures (including a &lt;0.3 m engineered cover and water control structures) is prepared by a professional engineer and approved by the Water Board as necessary. b) Engineered closure works are constructed according to design and as-built reports are prepared by the engineer. c) Facility (including perimeter embankments, water control structures and instrumentation) is routinely monitored according to design and under the direction of a professional engineer. d) Facility is periodically inspected and cumulative monitoring data reviewed against design by a professional engineer. e) Inspection reports are prepared by the engineer including recommended maintenance work and recommended adjustments to the monitoring program. f) Recommended maintenance work is implemented by the owner or otherwise addressed in a timely manner. g) As-built reports, monitoring results, inspection reports and maintenance descriptions are provided to the Water Board. h) Post-Closure monitoring and inspection program proceeds for a minimum of three years and then progressively decreases in scope and frequency based on demonstrated stability, in coordination with the site-wide Post-Closure monitoring program, and in accordance with recommendations of the engineer.</td>
<td>North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A)</td>
<td>Remedial actions to meet design as recommended by a professional engineer</td>
</tr>
<tr>
<td>NP2 - Physically stable PK containment area to limit risk of failure that would affect safety of people or wildlife.</td>
<td>Acceptable results, as identified in NP1, of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A)</td>
<td>Remedial actions to meet design as recommended by a professional engineer</td>
</tr>
<tr>
<td>UG1 - Flooding of the underground mine will have no impacts to aquatic habitat and community in source lakes.</td>
<td>This objective will be achieved through successful implementation of SW3.</td>
<td>Aquatic Effects Monitoring Program (Golder, 2019d, see Section 8 for Response Framework)</td>
<td>Human Health and Ecological Risk Assessment to assess potential effects</td>
</tr>
<tr>
<td>UG2 - Underground mine should not contribute to the contamination of ground or surface water.</td>
<td>The removal of all potential contaminant sources was completed prior to flooding in consultation with the GNWT Inspector. This objective will be demonstrated through Post-Closure monitoring as described in SW3 2.</td>
<td>Surveillance Network Program (SNP) Aquatic Effects Monitoring Program (Golder, 2019d, see Section 8 for Response Framework)</td>
<td>Human Health and Ecological Risk Assessment to assess potential effects</td>
</tr>
<tr>
<td>UG3 - Underground mine workings are physically stable.</td>
<td>Prior to flooding, the Mine was physically stable in accordance with the WSCC NWT’s Mines Act requirements. All Mine openings to surface, and permanent seals, will be designed and inspected in accordance with NWT Mines Act and associated regulations and will be constructed and inspected for a minimum of three years Post-Closure by a professional engineer.</td>
<td>Annual Site-Wide Geotechnical Inspections</td>
<td>Remedial actions to meet portal/raise cap design as recommended by a professional engineer</td>
</tr>
<tr>
<td>I1 - Prevent remaining infrastructure from contaminating land or water</td>
<td>Following the completion of a Hazardous Substances Assessment all potentially hazardous materials will be removed off-site to an approved disposal facility or treated on-site as per the approved Waste Management Plan. Any residual soil contamination will be addressed as described in 13.</td>
<td>Waste inventories and QA/QC program</td>
<td>Identify source of contamination. Evaluate options to relocate or cover source. Reshape area to promote positive drainage as required.</td>
</tr>
<tr>
<td>I2 - On-site disposal areas are safe for people, wildlife, and vegetation.</td>
<td>Any on-site disposal area (i.e., North Pile Landfills) will be designed and constructed by a professional engineer. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
<td>Waste inventories and QA/QC program North Pile Closure Monitoring Program (De Beers, 2019e, see Appendix A) Annual Site-Wide Geotechnical Inspections</td>
<td>Additional cover material to meet design Remedial actions to meet design as recommended by a professional engineer</td>
</tr>
<tr>
<td>I3 - Contaminated soils and waste disposal areas that cannot contaminate land and water.</td>
<td>Contaminated soil areas at the Mine are remediated in accordance with the GNWT Environmental Guideline for Contaminated Site Remediation, the approved Waste Management Plan, and to the satisfaction of a professional engineer or geoscientist.</td>
<td>Waste inventories and QA/QC program Environmental Hazards Assessment</td>
<td>Risk assessment and remedial action plan developed as necessary</td>
</tr>
</tbody>
</table>
6. PROGRESSIVE RECLAMATION

Progressive reclamation serves to decommission Mine components and/or reclaim Mine areas that are no longer required for operations, and the approach has been integrated by De Beers through the initial EA process and subsequent annual operational and closure planning. These reclamation activities have been used to enhance environmental protection of the site and to inform plans for permanent closure. The following section provides a summary of progressive reclamation that has already occurred, and identifies opportunities for continued progressive reclamation that may occur during ECM, prior to the start of Closure.

6.1 Definition of Progressive Reclamation

Progressive reclamation is defined as follows:

“Progressive reclamation takes place prior to permanent closure to reclaim components and/or decommission facilities that no longer serve a purpose. These activities can be completed during operations with the available resources to reduce future reclamation costs, minimize the duration of environmental exposure, and enhance environmental protection. Progressive reclamation may shorten the time for achieving closure objectives and may provide valuable experience on the effectiveness of certain measures that might be implemented during permanent closure” (MVLWB et al., 2013).

6.2 Opportunities for Progressive Reclamation

Progressive reclamation activities that have been completed at site to date are summarized in Section 6.3. As part of ECM, site infrastructure has been shut-down and mothballed. DeBeers has established a remote monitoring network so that the site can operate unmanned through the winter months. There is limited opportunity for further progressive reclamation to occur prior to the start of Closure; however, De Beers will continue to assess the Snap Lake Mine for:

- Further optimization of ECM activities;
- To actively seek to reduce the impacts to the environment and advance progressive reclamation by removing non-essential infrastructure; and
- To prepare for the final Closure of the Snap Lake Mine.

Any substantial alterations of this Extended Care and Maintenance Plan and associated management plans will be filed for stakeholder comment and MVLWB approval prior to implementing.

6.3 Completed Progressive Reclamation

Reclamation activities that have been completed to date at the Snap Lake Mine are summarized below (see Figure 6.1 for map of activities):

- In 2006, the former North Pit was backfilled with metavolcanic rock removed from surface during construction activities, then covered with at least 2 m of quarried granitic rock (De Beers, 2006). Since
this time the area has been used as a storage pad. Water quality monitoring in this area is completed within the framework of the Surveillance Network Program.

- In response to overtopping of Temporary Sump 4 with seepage water from the North Pile, a soil investigation was completed at the spill area to determine the presence of any residual contamination (Arktis, 2012a).
- No further reclamation activities are recommended for the spill area.
- In 2011, decommissioning of the temporary construction camp commenced with demolition, consolidation of materials, and preparation of contents to be mobilized off-site during subsequent winter road seasons.
  - Reclamation of the area continued in 2012 with the completion of the following activities:
    - Demobilization of construction camp materials off-site by winter road.
    - Confirmatory environmental sampling and analysis of pad materials (Arktis, 2012b).
    - Development of a construction plan for revegetation research field plots at the vacant pad area (Arktis, 2012c).
- In 2011, contaminated granular material was removed and confirmatory soil sampling and analysis was completed at the former Ammonium Nitrate (AN) Storage Pad (De Beers, 2011).
- In 2012, various concerns regarding the elevated concentrations of ammonium, nitrate and nitrite in pooled surface water at the Emulsion Plant Area were raised by the AANDC Inspector. To address these concerns, the following reclamation activities were completed:
  - Emulsion Plant Pad and Sump Assessment (Arktis, 2013b).
  - No further remedial activities were warranted at the time. These results will be incorporated into the Environmental Hazards Assessment completed during Closure (see Section 5.3.1).
- Revegetation test plots were established to support reclamation research at the former AN Storage Pad. This work has continued to advance, with application of additional native shrub seeds and seedlings, as well as monitoring of revegetation growth (Appendix J.2, Arktis, 2017c). A preliminary assessment of vegetative natural recovery about the mine site where there has been land disturbance from operations was also completed. These research findings have informed the Final Revegetation Plan (see Section 5.3.1, and Appendix J.1).
- The design of an engineered cover for the Starter Cell of the North Pile commenced in 2013 and was advanced through pre-feasibility to the detailed design stage in 2018 (Appendix H.1, Golder, 2019a).
- The following activities have been completed during care and maintenance in support of North Pile closure planning:
  - In 2016, an erosion protection layer of non-PAG rock was constructed on the outer perimeter embankments of the Starter and East Cells (Golder, 2016c).
In 2017, additional erosion protection material was placed on the East Cell upstream slope and along cuts through the interior rib berms for surface water drainage (Golder, 2018c).

Closure cover trial pads were constructed in July 2018 on the Starter and East Cells to assess settlement response (Golder, 2018f, Appendix H.3).

- To confirm if the landfarm area located within the footprint of the North Pile requires remediation, sampling and analysis of the soils was completed in 2015 (De Beers, 2015b) to support the development of an appropriate approach to decommissioning. As a result, petroleum hydrocarbon contaminated material has been identified within the landfarm and will require remediation. This work will occur as part of the Environmental Hazards Assessment (see Section 5.3.1).

- The Main Camp fire suppression system and glycol loop heating system were decommissioned in 2017 in an effort to reduce power consumption and better align with future ECM activity.

- Major structures, fixed and mobile equipment and hazardous materials were removed from underground as preparation for flooding in 2016 and 2017 (GNWT, 2017; De Beers, 2017f).

- Sequential flooding of the underground workings commenced in January 2017, and was completed by May 2017 (GNWT, 2017; De Beers, 2017f). The underground is fully closed and flooded, with the exception of access points, which require final closure.

- Removal of select materials from site over the winter road in 2017 (redundant mining inventory and heavy equipment).

At present, progressive reclamation at Snap Lake has not occurred to a level upon which its performance can be evaluated against the closure objectives/criteria, and as such, no Reclamation Completion or Performance Assessment reports have been submitted to the MVLWB. However these progressive reclamation activities (e.g., flooding the underground mine) have been important in allowing the site to achieve zero-occupancy care and maintenance, and informing advancement of closure planning from conceptual design to detailed design. Lessons learned as outcomes of the site specific progressive reclamation, have been directly incorporated into the advancement of the designs included in the FCRP (see cross-references listed above); as lessons learned from other regional mines are captured in Appendix D.1.
Figure 6.1 Snap Lake Progressive Reclamation Activities
7. TEMPORARY CLOSURE

This section is not applicable since the site is undergoing permanent closure. Extended Care and Maintenance Plan v3 (De Beers, 2018d) is intended to remain in effect at the site until the initiation of the Closure phase.
8. INTEGRATED SCHEDULE OF ACTIVITIES FOR PERMANENT CLOSURE

Snap Lake Mine has been in a state of temporary closure since the cessation of mine production in December 2015, and is currently operating in accordance with the MVLWB approved Extended Care and Maintenance Plan (De Beers, 2018d). De Beers has subsequently announced its intent to enter into final Mine Closure and to submit an FCRP to the MVLWB in Q1 2019.

For the purposes of planning and scheduling closure and reclamation, two phases are defined, as follows:

- The **Closure phase** consists of the activities required to prepare the site for the final closure condition, including decommissioning, demolition, development of the closure water management system and active site revegetation. These activities are described in Sections 5.2 and 5.3. The Closure phase is considered to begin once a Water Licence for closure has been granted by the MVLWB. Once the closure activities are considered complete and active management of the site is no longer required, the site transitions to Post-Closure.

- The **Post-Closure phase** consists of on-going monitoring of the site to confirm that the required closure condition has been developed and to demonstrate achievement of the closure objectives. Contingency actions may be required during this phase but no active management of the site is planned. Post-Closure monitoring, maintenance and contingency planning are described in Sections 5.5 and 5.6.

The FCRP outlines the schedule of activities through the execution of closure measures during the Closure phase, followed by the Post-Closure monitoring activities, and lastly to site relinquishment. Through the preparation of the FCRP, initial planning for the execution of closure measures has been completed, including the development of demolition and reclamation plans. Following submission of the FCRP, De Beers anticipates a one year regulatory approval process for the Closure Type A Water Licence, which will take place throughout 2019 and early 2020, prior to starting Closure. Closure execution will begin with the covering of the North Pile and transitioning of the existing water management systems to those required for passive management, followed by demolition of remaining site infrastructure and final reclamation of disturbed areas.

8.1 Closure

The Closure phase is characterized by the execution of closure activities, such as decommissioning, demolition, and material disposal of existing mine components, followed by site grading, landforming, and reclamation/revegetation of affected areas. The Closure phase will also involve the construction of new features, such as water conveyances and passive treatment systems, required for long-term water management at the site. Closure activities will involve all mine components, and are envisioned to take place over approximately 8 years, following receipt of regulatory approvals.

Given uncertainty in the length of time required for the constructed wetlands to mature, construction and development of the long-term water management system is prioritized in the early years of Closure. These up-front work packages include covering of the North Pile, re-development of the water conveyances to the closure condition, and construction of the ISPs and the wetlands. Contingency water treatment will remain in place while the passive treatment system is constructed and the wetlands mature. During this maturation
period, demolition activities will be conducted to remove site structures, followed by remediation, reclamation and revegetation activities.

Environmental monitoring programs will continue throughout the Closure phase as described in Section 5.5. Routine reports will be submitted to the Board, summarizing reclamation progress and the results of ongoing monitoring programs.

The following sub-sections outline the key activities on-going during the Closure timeline.

**Years 1 to 2**

Initial years will focus on the construction of the wetlands, ISPs and water conveyance structures between sumps required for water management from the North Pile. A winter road will be constructed in Year 1 to mobilize equipment to the site for these construction activities.

The preparation and movement of materials associated with the North Pile cover systems will occur in parallel and be integrated with the construction of the passive water treatment systems. These activities will include excavation and regrading of PK within the Starter and East Cells, for the purpose of achieving targeted slopes for closure, and to prepare for the installation of the engineered cover. As borrow materials become available, the engineered cover will be placed.

The landfill area, located within the footprint of the North Pile, will be prepared to receive demolition wastes. The final cover over the landfill will not be constructed until demolition and remediation of the site has been completed.

**Years 2 to 4**

Following wetland and water conveyance construction, monitoring and maintenance will be on-going to support wetland maturation. It is anticipated that maturation and achievement of design criteria may take up to 5 years (Golder, 2019b). The existing water treatment system will remain in operation until wetland performance is confirmed.

During this period, following the completion of construction of water conveyances and treatment wetlands, a Reclamation Completion Report may be submitted to the Board. This report will include details of the final designs and as-builts.

**Years 5 to 7**

At the beginning of this period a second winter road will be prepared to facilitate the mobilization of equipment to the Mine to commence demolition activities. Prior to demolition of structures, contents of buildings will be stripped - equipment and salvageable materials will be extracted for resale or recycling. Equipment will be decommissioned and, where applicable, decontaminated prior to removal. Hazardous materials and cleaning agents will be collected for offsite disposal. The landfill will begin to receive non-salvageable wastes from building contents stripping in Year 5. Demolition of onsite buildings and structures will begin as contents are removed. Concrete pads and other concrete structures will be broken or relocated to the landfill. Mine openings such as ventilation raises and mine portals will be sealed with an engineered cap (Appendix G.2).
By the end of this period, it is anticipated that maturation and performance demonstration of the constructed wetlands will be completed, and that effluent will be discharged to Snap Lake from the passive treatment system. Contingency water treatment systems will remain in place until performance is confirmed.

**Years 6 to 8**

In the final years of Closure, the existing water treatment system will be removed and final demolition completed. The landfill engineered cover will be constructed following the cessation of demolition activities. Site grading and landforming will then be completed. Revegetation and seeding of graded areas will occur once final landforms have been established.

### 8.2 Post-Closure

In Year 1 of Post-Closure, the winter road is constructed for a final time to allow all remaining equipment to demobilize from the site, signifying that the all closure activities have been completed. A Reclamation Completion Report will be submitted to the MVLWB during Year 1 of Post-Closure to demonstrate the completion of closure and reclamation activities at the site. Following submission of the Reclamation Completion Report, DeBeers will submit a request for bond release for the closure activities completed.

The Post-Closure phase is largely defined by its environmental monitoring and reporting programs, which are implemented following the completion of closure and reclamation activities. The monitoring programs are developed with the intention of demonstrating the achievement of closure criteria, and will remain ongoing until the respective closure criteria and objectives have been attained.

De Beers anticipates that up to 5 years of Post-Closure monitoring for some environmental aspects will be required in order to demonstrate that all closure criteria have been realized, with objectives being evaluated at Years 3 and 5 of Post-Closure. Where closure objectives have not been achieved by Year 5, monitoring will be continued and evaluated for completion every five years thereafter, up until Year 20. Performance Assessment Reports will be submitted to the MVLWB demonstrating the achievement of closure objectives and will provide DeBeers the opportunity to submit a request for bond release. Upon achievement of all closure objectives, relinquishment of the land leases associated with the Mine may be pursued.

The integrated schedule of activities for mine closure is depicted in Figure 8.1, and demonstrates the duration of the various closure activities taking place throughout the Closure and Post-Closure phases.

The achievement of the closure criteria and closure objectives for all environmental aspects will mark the completion of the Post-Closure phase, and signal the opportunity to relinquish the land leases to the Crown. De Beers has allowed 2 years for complete full relinquishment of the Snap Lake Mine site.
Figure 8.1   Integrated Schedule of Closure Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>ECM Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
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<th>Year 8</th>
<th>Year 9</th>
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<th>Year 20</th>
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<tr>
<td>Water Licence Approval Process</td>
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<td>Winter Road Construction</td>
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<td>Water Management System and North Pile Construction</td>
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<td>Passive Water Treatment System Commissioning</td>
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<td>Active Demolition</td>
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<td>Revegetation, Landforming, and Site Stabilization</td>
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<td>Post Closure Environmental Monitoring Programs</td>
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De Beers Group
9. POST-CLOSURE SITE ASSESSMENT

Following the completion of Closure activities described in Section 5.3, the site will enter the Post-Closure phase. This phase begins once active management of the site is no longer required and is defined by the implementation of monitoring and maintenance programs, which are developed to demonstrate achievement of closure objectives and closure criteria, ensuring the successful reclamation and long term closure of the site.

9.1 Assessment Approach

As described in Section 5.4 (Predicted Residual Effects) and Appendix I (Human Health and Ecological Risk Problem Formulation), achievement of the closure objectives and criteria will ensure that Closure and Post-Closure environmental effects are minimized and remain consistent with the conclusions of the EAR. Therefore, the Post-Closure site assessment is focused upon monitoring and confirming progress towards achievement of these objectives and criteria.

In order to ensure that site conditions are on track to reaching the closure objectives, a set of success indicators has been established to serve as targets which must be demonstrated at each phase of mine closure. The success indicators are the agreed upon standards that demonstrate whether actual closure performance is progressing over time (as expected at the design phase), in order to meet closure criteria and facilitate lease relinquishment. They include physical and biophysical parameters and have been generally defined through engagement with regulators and other external stakeholders.

The following principles have been defined for the development of success indicators:

- Meet rehabilitation objectives;
- Landforms are integrated into the surrounding landscape and are non-polluting;
- Rehabilitation exhibits sustained growth and is resilient; and
- Management of rehabilitation can be integrated with surrounding areas and requires no additional ongoing resources;

Each of the success indicators are aligned with the closure criteria, and tracked through the Post-Closure period to ensure that observed site conditions have progressed as expected. The Post-Closure phase is subdivided into periods of time where milestone achievements are anticipated to be reached. These sub-phases are anticipated to take place at Post-Closure Years 3 and 5, and Years 10, 15 and 20 if required. These sub-phases identify ‘check in’ points where reclamation progress will be measured against the success indicators. Where site conditions align with the success indicators, monitoring results are evaluated against the closure criteria. Where closure criteria have not yet been achieved, monitoring will continue, and will be re-evaluated at the following ‘check-in’ point. Where the closure criteria have been attained, and the closure objective satisfied, the successful reclamation of that environmental aspect has been achieved and monitoring will be discontinued. Where monitoring programs demonstrate that success indicators have not been reached at the ‘check-in’ point, the corrective actions described in Section 5.6 will be implemented to guide the site toward attaining the success indicators at the following ‘check-in’ period.
Table 9.1 demonstrates the developed success indicators and closure objectives across the Post-Closure phase. The success indicators are assigned to the mine components and relate back to the specific closure criteria, described in Table 5.3.

9.2 Completion Reporting

9.2.1 Reclamation Completion Report

The Reclamation Completion Report will provide details of the reclamation work completed at the site (including figures and photos), containing an inventory of infrastructure removed, engineered as-built reports, an explanation of deviations from the approved design, and an inventory of remaining infrastructure. The report will also include a preliminary assessment on the achievement of closure objectives and criteria, and will provide a description (including timeline) of Post-Closure monitoring programs. With the reclamation completion report, there may be an opportunity to revise the financial security estimate (MVLWB et al., 2013). It is possible that an interim Reclamation Completion Report may be submitted if substantive reclamation work is completed in advance of the completion of the Closure phase. This is discussed further in Section 10.

9.2.2 Performance Assessment Report

Performance Assessment Reports will provide an evaluation of site conditions against the closure objectives and criteria, and will be prepared after a time period where the performance of the reclamation effort can be adequately assessed. The Performance Assessment Report will provide details of the following:

- updated photographs of the site and reclaimed components;
- updated human and wildlife health and safety condition;
- descriptions of engagement and community participation in site monitoring;
- maintenance and/or management activities; and
- any associated updates to the closure and reclamation cost estimate.

With each performance assessment report, there may be an opportunity to revise the security estimate (MVLWB et al., 2013).

The report will summarize the results of the site assessment and identify areas where site conditions align with the success indicators, and whether corrective actions will be implemented to improve performance. Where site conditions and success indicators concur, the Performance Assessment Report will identify whether closure objectives have been achieved. Where closure objectives have been achieved, De Beers will discontinue monitoring for that environmental aspect, and will present a revision to the Post-Closure monitoring programs presented in Table 5.6.

Where site conditions and success indicators do not align, the Performance Assessment Report will include details of the corrective actions to be implemented, and proposed modifications to the applicable Post-Closure monitoring programs. Measurement of the site conditions will be reassessed against the success indicators at the following ‘check-in’ period.
Table 9.1  Post-Closure Success Criteria

<table>
<thead>
<tr>
<th>Objective</th>
<th>Criteria</th>
<th>Primary Reclamation Activities</th>
<th>Key Monitoring Programs</th>
<th>Routine Reporting</th>
<th>Success Indicators</th>
<th>Potential Corrective Actions</th>
<th>Completion Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Wide</td>
<td></td>
<td></td>
<td>Engineering design and construction of a cover placed over the North Pile</td>
<td>Air Quality and Emissions Monitoring and Management Plan</td>
<td>Air Quality, Meteorological Monitoring and Emissions Reporting Annual Report</td>
<td>No exceedance of standards/guidelines as demonstrated through monitoring program</td>
<td>Identify source of dust. Roadway and revegetated area as required. Infl. work brown, if required. Performance Assessment Report to be submitted at Year 3.</td>
</tr>
<tr>
<td>SW2 – Surface runoff and stability</td>
<td></td>
<td></td>
<td>Final grading where required to promote positive drainage</td>
<td>Final grading where required to promote positive drainage</td>
<td>Water licence Annual Report KMP Report</td>
<td>EQOs are met in surface discharge as demonstrated through monitoring. SSQWOs are achieved in the receiving environment as demonstrated through monitoring with no evidence to suggest temporal trends that could lead to exceedence.</td>
<td>Continuous to operate water treatment systems during wetland testing. Inject water to underground. Human Health and Ecological Risk Assessment to assess potential effects.</td>
</tr>
<tr>
<td>SW3 – Surface runoff and stability</td>
<td></td>
<td></td>
<td>Surveillance Network Program (SNP) Hydrology Monitoring Plan</td>
<td>Surveillance Network Program (SNP) Hydrology Monitoring Plan</td>
<td>Hydrology Monitoring Plan</td>
<td>EQOs are met in surface discharge as demonstrated through monitoring. SSQWOs are achieved in the receiving environment as demonstrated through monitoring with no evidence to suggest temporal trends that could lead to exceedence.</td>
<td>Reclamation Completion Report for passive water system construction. Performance Assessment Report to be submitted at Year 5 if criteria met.</td>
</tr>
<tr>
<td>SW4 – Mine areas</td>
<td></td>
<td></td>
<td>Final grading where required to promote positive drainage</td>
<td>Final grading where required to promote positive drainage</td>
<td>Water licence Annual Report KMP Report</td>
<td>EQOs are met in surface discharge as demonstrated through monitoring. SSQWOs are achieved in the receiving environment as demonstrated through monitoring with no evidence to suggest temporal trends that could lead to exceedence.</td>
<td>Continuous to operate water treatment systems during wetland testing. Inject water to underground. Human Health and Ecological Risk Assessment to assess potential effects.</td>
</tr>
<tr>
<td>SW5 – Landscape features (shape and vegetation) match aesthetics of the surrounding natural area.</td>
<td></td>
<td></td>
<td>Removal of all buildings, equipment, and non local materials remaining on site</td>
<td>Reclamation Completion Report for passive water system construction.</td>
<td>Reclamation Completion Report for passive water system construction.</td>
<td>EQOs are met in surface discharge as demonstrated through monitoring. SSQWOs are achieved in the receiving environment as demonstrated through monitoring with no evidence to suggest temporal trends that could lead to exceedence.</td>
<td>Reclamation Completion Report for passive water system construction. Performance Assessment Report to be submitted at Year 3.</td>
</tr>
</tbody>
</table>

Closure Monitoring

Planning, implementation and monitoring of the post closure monitoring plan to be undertaken in accordance with the approved post closure monitoring plan and approved by professional.

Post Closure Monitoring

Monitoring programs planned, and conducted as designed, as per requirements of the approved post closure monitoring plan and as per professional

Reclamation Completion

Report to be submitted at Year 5 if criteria met.

Key monitoring programs include:

- Hydrology Monitoring Plan
- Geotechnical Inspections
- Annual Site Monitoring Program
- Vegetation Monitoring Program
- Wildlife Effects Monitoring Program
- AEMP Report
- Water Licence Annual Report

Potential Corrective Actions

- Repair areas of visible erosion
- Stabilise/secure areas of ponded water or obstructed conveyance
- Re-seed as required.
- SFM's required.
- SFM's required.
- SFM's required.
- SFM's required.
- SFM's required.
- SFM's required.
- SFM's required.
SNAP LAKE MINE

1. **Physical Stability**
   - Required through engineering design. A 3:1 slope in mine-impacted areas will be achieved to facilitate cutback passage. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.
   - Engineered earthen structures remaining at the site (i.e., North Pile) will be physically engineered. NP closure objectives below for details specific to stability of mine waste areas.
   - Mitigation of environmental risk to wildlife from surface material pooling, surface material loosening, placement of spilled overburden as a result of overburden placed in the Fish Habitat Compensation Plan developed in consultation with DFO.

2. **Chemical Stability**
   - Not applicable as this is a physical objective; chemical stability is addressed under SW3 and SW4.
   - Chemical contamination remaining in the North Pile engineered cover design.

3. **Future Use and Aesthetics**
   - Future use and aesthetic objectives are met through physical criteria as described in SW5-1.

---

**Objective:** North Pile

1. **Physical Stability**
   - Closure design of engineered structures (including a 10.0 m cover and water control structures) is prepared by a professional engineer and approved by the Water Board as necessary.
   - Grading surfaces to promote drainage and limit pooling, surface material lossing identification, placement of spilled overburden as a result of overburden placed in the Fish Habitat Compensation Plan developed in consultation with DFO.

2. **Chemical Stability**
   - Not applicable as this is a physical objective; chemical stability is addressed under site wide and infrastructure objectives (SW2, SW4, SW7, SW12).
   - Chemical contamination remaining in the North Pile engineered cover design.

3. **Future Use and Aesthetics**
   - As demonstrated by re-vegetation research.
   - Reshape and reseed as required.

---

**Objective:** Final Closure

1. **Physical Stability**
   - Removal of all buildings, equipment, and surface hazards.
   - Final landscape inspected and submission of as-built survey to confirm final landscape in accordance with design.

2. **Chemical Stability**
   - Engineered earthen structures remaining at the site (i.e., North Pile) will be physically engineered. NP closure objectives below for details specific to stability of mine waste areas.
   - Mitigation of environmental risk to wildlife from surface material pooling, surface material loosening, placement of spilled overburden as a result of overburden placed in the Fish Habitat Compensation Plan developed in consultation with DFO.

---

**Performance Assessment Report to be submitted at Year 3:**

- Reclamation Completion Report for general site area landforms and reclamation activities.
- Reclamation Completion Report for North Pile cover and water conveyance.

---

**Criteria**

<table>
<thead>
<tr>
<th>SW5 – Safe passage and use for Caribou and other wildlife.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Physical Stability</strong></td>
</tr>
<tr>
<td>- When possible through engineering design, a 3:1 slope in mine-impacted areas will be achieved to facilitate cutback passage. Acceptable results of visual monitoring for deformation and degradation for a minimum of three years Post-Closure as part of site geotechnical inspections completed and signed off by a professional engineer.</td>
</tr>
<tr>
<td>2. <strong>Chemical Stability</strong></td>
</tr>
<tr>
<td>- Not applicable as this is a physical objective; chemical stability is addressed under SW3 and SW4.</td>
</tr>
<tr>
<td>3. <strong>Future Use and Aesthetics</strong></td>
</tr>
<tr>
<td>- Future use and aesthetic objectives are met through physical criteria as described in SW5-1.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>SW7 – Revegetation targeted to priority areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Physical Stability</strong></td>
</tr>
<tr>
<td>- Not applicable as this is a future use and aesthetic objective as described in SW7-3. Physical stability is addressed through site wide and infrastructure objectives (SW2, SW4, SW7, SW12).</td>
</tr>
<tr>
<td>2. <strong>Chemical Stability</strong></td>
</tr>
<tr>
<td>- Not applicable as this is a future use and aesthetic objective as described in SW7-3. Chemical stability is addressed through site wide and infrastructure objectives (SW3, SW4, SW12).</td>
</tr>
<tr>
<td>3. <strong>Future Use and Aesthetics</strong></td>
</tr>
<tr>
<td>- As demonstrated by re-vegetation research.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>North Pile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Physical Stability</strong></td>
</tr>
<tr>
<td>- Closure design of engineered structures (including a 10.0 m cover and water control structures) is prepared by a professional engineer and approved by the Water Board as necessary.</td>
</tr>
<tr>
<td>2. <strong>Chemical Stability</strong></td>
</tr>
<tr>
<td>- Chemical contamination remaining in the North Pile engineered cover design.</td>
</tr>
<tr>
<td>3. <strong>Future Use and Aesthetics</strong></td>
</tr>
<tr>
<td>- As demonstrated by re-vegetation research.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>Final Closure and Reclamation Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Physical Stability</strong></td>
</tr>
<tr>
<td>- Removal of all buildings, equipment, and surface hazards.</td>
</tr>
<tr>
<td>2. <strong>Chemical Stability</strong></td>
</tr>
<tr>
<td>- Engineered earthen structures remaining at the site (i.e., North Pile) will be physically engineered.</td>
</tr>
<tr>
<td>3. <strong>Future Use and Aesthetics</strong></td>
</tr>
<tr>
<td>- Final grading will reflect surrounding topography.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>De Beers Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Physical Stability</strong></td>
</tr>
<tr>
<td>- As demonstrated by re-vegetation research.</td>
</tr>
<tr>
<td>2. <strong>Chemical Stability</strong></td>
</tr>
<tr>
<td>- As demonstrated by re-vegetation monitoring.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Closure (Years 1-3)</td>
</tr>
<tr>
<td>Final closure monitoring and maintenance report</td>
</tr>
<tr>
<td>As-built survey to confirm final landscape in accordance with design.</td>
</tr>
<tr>
<td>Remediation actions to meet design as recommended by a professional engineer.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Closure (Years 5-20)</td>
</tr>
<tr>
<td>Final closure monitoring and maintenance report</td>
</tr>
<tr>
<td>As-built survey to confirm final landscape in accordance with design.</td>
</tr>
<tr>
<td>Remediation actions to meet design as recommended by a professional engineer.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Closure (Year 3)</td>
</tr>
<tr>
<td>Final landscape inspected and submission of as-built conditions in a summary report completed by a professional engineer.</td>
</tr>
<tr>
<td>Remediation actions to meet design as recommended by a professional engineer.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Assessment Report to be submitted at Year 3.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reclamation Completion Report for general site area landforms and reclamation activities.</td>
</tr>
</tbody>
</table>

---

**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reclamation Completion Report for North Pile cover and water conveyance.</td>
</tr>
</tbody>
</table>

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**Criteria**

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</tr>
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<tr>
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<tbody>
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</tbody>
</table>

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</tr>
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<tbody>
<tr>
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</tbody>
</table>

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**Criteria**

<table>
<thead>
<tr>
<th>March 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reclamation Completion Report for North Pile cover and water conveyance.</td>
</tr>
</tbody>
</table>
# Final Closure
## SNAP LAKE MINE

### Underground Mine

<table>
<thead>
<tr>
<th>Objective</th>
<th>Criteria</th>
<th>Primary Reclamation Activities</th>
<th>Key Monitoring Programs</th>
<th>Routine Reporting</th>
<th>Success Indicators</th>
<th>Potential Corrective Actions</th>
<th>Completion Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UG1 - Flooding of the underground mine will have no impacts to aquatic habitat and community in source lakes.</strong></td>
<td>1. Physical Stability</td>
<td>Not applicable as physical stability of the underground mine is addressed in UG3.</td>
<td>Aquatic Effects Monitoring Program (AEMP)</td>
<td>AEMP Report</td>
<td>see UG2, UG3, SW3</td>
<td>Human Health and Ecological Risk Assessment to assess potential effects if guidelines not met.</td>
<td>Performance Assessment Report to be submitted at Year 20.</td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>Not applicable as chemical stability of the underground mine is addressed in UG2.</td>
<td>Surveillance Network Program (SNP)</td>
<td>Aquatic Effects Monitoring Program (AEMP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Not applicable as future use and aesthetics objectives will be achieved through SW3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UG2 - Underground mine should not contribute to the contamination of ground or surface water.</strong></td>
<td>1. Physical Stability</td>
<td>Not applicable as physical stability of the underground mine is addressed in UG3.</td>
<td>Surveillance Network Program (SNP)</td>
<td>Water License Annual Report</td>
<td>EQCs are met in surface discharge monitoring. SWQOs are achieved in the receiving environment through monitoring with no evidence to suggest temporal trends that could lead to exceedance.</td>
<td>Human Health and Ecological Risk Assessment to assess potential effects</td>
<td>Performance Assessment Report to be submitted at Year 20.</td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>The removal of all potential contaminant sources was done prior to flooding in consultation with the GNWT Inspector. This objective will be demonstrated through Post-Closure monitoring as described in SW3-2.</td>
<td>Water License Annual Report</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Not applicable as future use and aesthetics objectives will be achieved through UG2-2 and SW3-2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UG3 - Underground mine workings are physically stable.</strong></td>
<td>1. Physical Stability</td>
<td>The mine was physically stable in accordance with the WSG2, WNT’s Fit for Activity requirements. All Mine openings to surface, and permanent seals, will be designed and inspected in accordance with WNT Mines Act and associated regulations and will be constructed and inspected for a minimum of three years Post-Closure by a professional engineer.</td>
<td>Annual Site Wide Geotechnical Inspections</td>
<td>Post-construction monitoring and maintenance report</td>
<td>Aerial survey demonstration of source concurrence with design. Stability closure criteria achieved as demonstrated by monitoring.</td>
<td>Remedial actions to meet portal/raise cap design as recommended by a professional engineer</td>
<td>Reclamation Completion Report for underground mine cap construction. Performance Assessment Report to be submitted at Year 3.</td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>Not applicable as chemical stability of the underground mine is addressed in UG2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetic objectives are met through physical criteria as described in UG3-1. Where appropriate, aesthetic considerations will be included in designs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Infrastructure

<table>
<thead>
<tr>
<th>Objective</th>
<th>Criteria</th>
<th>Primary Reclamation Activities</th>
<th>Key Monitoring Programs</th>
<th>Routine Reporting</th>
<th>Success Indicators</th>
<th>Potential Corrective Actions</th>
<th>Completion Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11 - Prevent remaining infrastructure from contaminating land or water.</strong></td>
<td>1. Physical Stability</td>
<td>Physical stability is addressed in SW4 and UG3.</td>
<td>Waste inventories and QA/QC program</td>
<td>Water License Annual Report</td>
<td>All contaminated sites and materials remediated as demonstrated through soil monitoring.</td>
<td>Identify source of contamination. Evaluate options to relocate or cover source. Redesign areas to promote positive drainage as required.</td>
<td>Reclamation Completion Report for Environmental Hazards Assessment. Performance Assessment Report to be submitted at Year 3.</td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>Physical stability is addressed in SW4 and UG3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetic objectives will be addressed through chemical stability criteria as described in 11-2.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>12 - Onsite disposal areas are safe for people, wildlife, and vegetation.</strong></td>
<td>1. Physical Stability</td>
<td>Onsite disposal areas (i.e., North Pile Landfill) will be designed and constructed by a professional engineer.</td>
<td>Waste inventories and QA/QC program</td>
<td>Water License Annual Report</td>
<td>All contaminated sites and materials remediated as demonstrated through soil monitoring.</td>
<td>Additional cover material to meet design. Remedial actions to meet design as recommended by a professional engineer.</td>
<td>Reclamation Completion Report for landfill construction and cover. Performance Assessment Report to be submitted at Year 3.</td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>Onsite disposal areas will be designed and constructed by a professional engineer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetic objectives will be met through physical criteria as described in 12-1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>13 - Contaminated soils and waste disposal areas that cannot contaminate land and water.</strong></td>
<td>1. Physical Stability</td>
<td>Physical stability is addressed through SW4 and UG3.</td>
<td>Waste inventories and QA/QC program</td>
<td>Water License Annual Report</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Chemical Stability</td>
<td>Any onsite disposal areas (i.e., North Pile Landfill) will be designed and inspected by a professional engineer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Future Use and Aesthetics</td>
<td>Future use and aesthetic objectives will be met through physical criteria as described in 12-1.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. **FINANCIAL SECURITY**

10.1 Financial Security Estimate

The financial security required under MVLWB-issued authorizations was adjusted by the MVLWB in June 2018 (MVLWB, 2018) following review of an updated reclamation security estimate that had been submitted by De Beers in response to a Directive issued by the MVLWB under Part C Condition 3 of the Water Licence. The currently required security of $78,963,088 has been provided to the GNWT through Irrevocable Letters of Credit (ILOCs) (GNWT, 2018b). The security is required and provided under two MVLWB-issued authorizations as follows:

- $27,844,664 required under Water Licence MV2011L2-0004 for water-related security; plus
- $51,118,424 required under Land Use Permit MV2017D0032 for land-related security.

An updated security estimate that aligns with the FCRP is provided in Appendix F. The updated security estimate was developed using the current version (Version 7) of the MVLWB-requested RECLAIM model and is consistent with MVLWB Guidelines for mine closure cost estimation (MVLWB, 2017a). The Summary page of the updated RECLAIM model is provided as Table 10.1 for ease of reference and the complete RECLAIM output is provided in Appendix F.

### Table 10.1 Financial Security Summary

<table>
<thead>
<tr>
<th>Capital Costs</th>
<th>Component Name</th>
<th>Cost</th>
<th>Land Liability</th>
<th>Water Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Pit</td>
<td></td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Underground Mine</td>
<td></td>
<td>$240,102</td>
<td>$240,102</td>
<td>$0</td>
</tr>
<tr>
<td>Tailings Facility</td>
<td></td>
<td>$6,766,283</td>
<td>$3,384,835</td>
<td>$3,381,448</td>
</tr>
<tr>
<td>Rock Pile</td>
<td></td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Buildings And Equipment</td>
<td></td>
<td>$16,392,319</td>
<td>$16,318,108</td>
<td>$74,211</td>
</tr>
<tr>
<td>Chemicals And Contaminated Soil</td>
<td>Management</td>
<td>$4,541,172</td>
<td>$2,270,586</td>
<td>$2,270,586</td>
</tr>
<tr>
<td>Surface And Groundwater Management</td>
<td></td>
<td>$18,137,342</td>
<td>$0</td>
<td>$18,137,342</td>
</tr>
<tr>
<td>Interim Care And Maintenance</td>
<td></td>
<td>$1,707,209</td>
<td>$0</td>
<td>$1,707,209</td>
</tr>
<tr>
<td><strong>Subtotal: Capital Costs</strong></td>
<td></td>
<td>$47,784,426</td>
<td>$22,213,630</td>
<td>$25,570,795</td>
</tr>
<tr>
<td><strong>Percent of Subtotal</strong></td>
<td></td>
<td></td>
<td>46%</td>
<td>54%</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobilization/Demobilization</td>
<td></td>
<td>$16,407,640</td>
<td>$7,627,449</td>
<td>$8,780,192</td>
</tr>
<tr>
<td>Post-Closure Monitoring And</td>
<td>Maintenance</td>
<td>$8,036,055</td>
<td>$3,735,735</td>
<td>$4,300,320</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td>5%</td>
<td>$2,389,221</td>
<td>$1,110,682</td>
</tr>
</tbody>
</table>
### Indirect Costs

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
<th>Land Liability</th>
<th>Water Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Management</td>
<td>$2,389,221</td>
<td>$1,110,682</td>
<td>$1,278,540</td>
</tr>
<tr>
<td>Health And Safety Plans/Monitoring and QA/QC</td>
<td>$477,844</td>
<td>$222,136</td>
<td>$255,708</td>
</tr>
<tr>
<td>Bonding/Insurance</td>
<td>$477,844</td>
<td>$222,136</td>
<td>$255,708</td>
</tr>
<tr>
<td>Contingency</td>
<td>$7,167,664</td>
<td>$3,332,045</td>
<td>$3,835,619</td>
</tr>
<tr>
<td>Market Price Factor Adjustment</td>
<td>0%</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

**Subtotal: Indirect Costs**

<table>
<thead>
<tr>
<th>Subtotal: Indirect Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$37,345,490</td>
</tr>
<tr>
<td>$17,360,864</td>
</tr>
<tr>
<td>$19,984,626</td>
</tr>
</tbody>
</table>

**Total Costs**

<table>
<thead>
<tr>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$85,129,915</td>
</tr>
<tr>
<td>$39,574,494</td>
</tr>
<tr>
<td>$45,555,421</td>
</tr>
</tbody>
</table>

The updated financial security estimate addresses the closure measures presented in this FCRP, including the following:

- Provision for an engineered cover over the North Pile;
- Provision for demolition of all buildings and facilities;
- Provision for on-site landfilling of inert demolition debris;
- Provision for remediation and/or removal of contaminated soils and hazardous materials;
- Provision for construction of wetlands;
- Provision for sealing of openings to the flooded underground workings;
- Provision for active water treatment during the Closure phase;
- Provision for revegetation; and
- Provision for Post-Closure monitoring.

## 10.2 Staged Reduction of Financial Security

The MVLWB 2013 Mine Closure Planning Guidelines (MVLWB et al., 2013) anticipate that financial security will be reduced in a staged manner as closure and reclamation activities proceed. Section 1.3 of those Guidelines states:

*When ongoing reclamation work reduces the outstanding environmental liability, it will result in a proportional reduction in the level of required financial security.*

The general schedule of reclamation activities (Figure 8.1) and the corresponding schedule of security value expended and remaining (Figure 10.1) illustrate clear milestones for appropriate times when the amount of security required through MVLWB-issued regulatory instruments should be reduced, as follows:

- **Stage 1 Security Reduction: End of Closure Phase (Year 8)**
  - All of the physical reclamation work and contractor winter road demobilization, which represents the majority of the security held, is scheduled to be complete by the end of Year 8, which effectively marks the end of the Closure phase. This includes building demolition, landfilling, earthworks
related to reclamation of the North Pile, and transition to passive release of runoff water from the reclaimed site.

- Completion of these activities represents a milestone that is targeted for reduction in security. The requested reduction would be in the order of ninety percent of the security held (approximately $77M per Table 10.1), which is representative of the security value of the activities completed.

- **Optional Stage 1a Security Reduction: Closure Phase (Year 2)**

  - A number of discretely costed activities are scheduled to be completed at the end of Year 2 of Closure, including construction of wetlands and influent systems, grading and preparation of the North Pile for covering, preparation of the demolition landfill, active water treatment, monitoring, and contractor winter road mobilization.

  - Completion of these activities represents a reduction in the order of forty percent of the security held (approximately $34M per Table 10.1), which is representative of the security value of the activities completed.

- **Stage 2 Security Reduction: Post-Closure Phase**

  - During Post-Closure, monitoring data will be collected on an ongoing basis in support of a final request for relinquishment. Staged security reductions will be requested periodically (i.e., once every 3-5 years) commensurate with the value of work completed towards final relinquishment and achievement of objectives. The scheduled duration of the Post-Closure phase is considered conservative at 20 years; however the actual duration may be longer or shorter and will be based on on-going monitoring results.

Each request for a staged reduction in security will be accompanied by a Reclamation Completion Report or Performance Assessment Report for work completed, will address MVLWB engagement and performance assessment expectations, and will be consistent with applicable MVLWB guidelines including the 2013 Closure Planning Guidelines (MVLWB et al., 2013) and the 2017 Mine Closure Costing Guidelines (MVLWB, 2017a).

### 10.3 Relinquishment

The ultimate outcome of the mine closure and reclamation process is relinquishment, described in the MVLWB 2013 Closure Planning Guidelines (MVLWB et al., 2013) (S.2.1.2, pg. 27) as follows:

> The closure and reclamation planning process occurs in an effort to achieve successful relinquishment. Relinquishment occurs when the Crown and/or the landowner release a proponent from liability associated with the project, typically resulting in a return of the security.

Where Post-Closure monitoring data indicates that staged relinquishment of individual areas of the mine site is appropriate, staged requests may be made on the basis of a final Performance Assessment Report for that area. In the case of a request for staged relinquishment of an individual part of the mine site, the request will be accompanied by a revised financial security estimate representative of remaining closure liabilities.
A request for full and final relinquishment, marking the end of the mine closure and reclamation process, will be made to the MVLWB accompanied by a Final Performance Assessment Report that demonstrates all closure objectives and goals have been achieved.

The initially anticipated timeframe for full and final relinquishment is illustrated on Figure 10.1.

**Figure 10.1  Conceptual Staged Reduction of Security**
11. REFERENCES

Alberta Environment and Sustainable Resource Development (AESRD), 2016. *Alberta Ambient Air Quality Objectives and Guideline Summary*.


Arktis, 2017c. *Quarry Volume Quantity Update*.


Department of Fisheries and Oceans Canada, 2013. Standard Operating Policies, Policy for the Management of Fish Habitat (renamed Fisheries Protection Program as of April 13, 2013), Chapter 5: Procedures to apply the No Net Loss Principle.


De Beers Group

Natural Resources Canada, 2018b. *Earthquake Map of Canada*.


